finishing

APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING
ANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES

Vol. 3 No. 29 (new series) MAY, 1957

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THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

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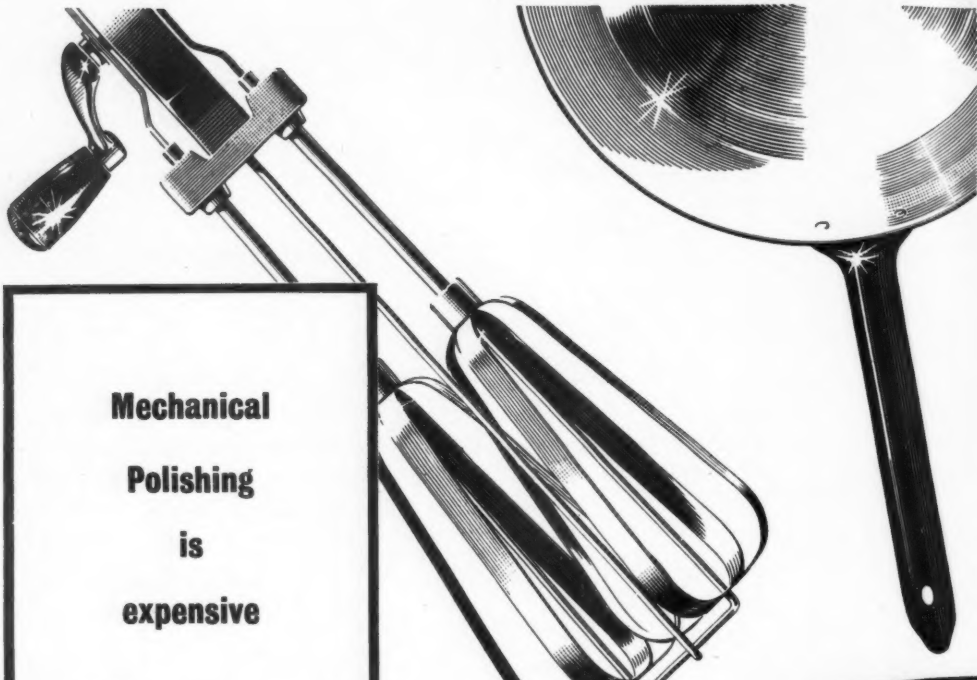

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AT LAST

THE emergence of new developments upon the industrial scene can take place with widely varying amounts of technical impact. The arrival of some developments is heralded by resounding fanfares acclaiming them as a massive technical advance. Others steal lightly upon the stage and may well remain unnoticed and unsought for lengthy periods. For some a keen demand exists prior to their appearance so that their arrival is welcomed and their offerings immediately put to use with varying degrees of success. For others no preliminary demand has been created and markets and applications are only slowly found and developed.

The invention and development of many processes of interest to the metal finishing industries is taking place in many countries other than the U.K., and perhaps largely in accordance with the principle that the steak on one's neighbour's plate always appears juicier and more tender than that on one's own, an increasing number of these processes is finding a ready market in this country.

This is to be welcomed where such processes have genuine advantages to offer and where their adoption can lead to improvements in quality or reductions in cost in the application of a finish. It can be assumed that where this is not the case the normal operation of industrial competition will eliminate inferior finishes from the running.

However, in the light of what has been said, it is noteworthy that there still exist demands for certain types of finish which have hitherto remained unsatisfied. One of these has been for a vitreous enamel capable of being applied to aluminium surfaces. It is now over ten years since the first results of experiments into the possibility of producing a vitreous enamel for application to aluminium were published, and there has been no lack since that time of expressions of interest in the availability for such a material.

For a very considerable number of years indeed, vitreous enamel on iron and steel has given an excellent account of itself and there are numerous examples of enamelled articles of great age with the original finish unmarred. For a number of reasons aluminium and its alloys are finding increasing application as the material used in the fabrication of numerous articles hitherto made of ferrous metal. In many of these applications the availability of a suitable vitreous enamel coating would have considerably enhanced the appearance and service life of the component. However, although spasmodic reports of success have emanated from the U.S.A. and Scandinavia, most of these have involved the use of lead-bearing frits which are largely unacceptable to the industry in this country.

It is, therefore, in response to a long-standing demand and on to a stage where the scenery has long been set that the announcement comes that a lead-free vitreous enamel firing at 538° *C suitable for application to aluminium is now commercially available in this country.*

The first technical details relating to the processing and application of these enamels, were provided during the Annual Refresher Course organized by one of the leading enamel frit suppliers in this country. The salient features of this information are published in abstracts from two of the lectures elsewhere in this issue.

The vitreous-enamel industry has given clear signs in past months of entering upon a new and wider range of activities. The fact that it can now include aluminium in its scope should give a fresh impetus to this trend.

Talking Points by "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

TOO EASY TO BE GOOD?

IT is interesting to see from a recent patent that bright chromium-nickel alloy deposits can be plated from a solution containing chromic acid and nickel chloride with a small amount of acetic acid. The ratio of chromium to nickel can be between 14 : 1 and 4 : 1. The current density is high, however, being not less than 400 amps. per sq. ft.

This is rather interesting news as alloys within this range are of the heat-resisting type. If the process can be carried out successfully, the gas turbine manufacturers might find applications for it. Mild steel combustion chambers are very good from the mechanical point of view, but cannot be used because of oxidation. If they could be coated with a heat-resisting non-porous nickel-chromium alloy of adequate thickness considerable economies might result in this field, as well as savings in nickel in comparison with the materials used at present.

There are probably considerable snags in operating the process in practice—there usually are! It looks altogether too easy.

STOPPING THE WIND

WHEN one hears of a very simple device which saves a lot of money, the inclination is rather to treat it in a cavalier fashion. Only the complicated and difficult developments get all our attention. A case in point is the very obvious system of a fan control unit which automatically cuts out the exhaust equipment from a spray booth whenever the gun is not in use. A delay of 1-2 minutes is allowed before the cut-out operates so as not to shut the fan off during normal operational stops, and to remove overspray when work finishes.

Yet a device of this kind would pay for itself over and over again in savings in heat and in the power required to drive the fan motor during the intervals of non-use of spray booths which occurs in many factories. This is apart from the question of wear and tear.

The makers should be inundated with orders—but will they? We shall know if the device finds imitators, which is always a good sign that an idea has caught on! I hope I shall be forgiven for commenting that this is as good a purpose as any for which to "raise the wind" to stop the wind!

FUEL FOR THOUGHT

THE proposal before Parliament to compel all new factories to be built to an approved standard of insulation to ensure that fuel is not wasted is a good one, although it is sure to meet with opposition. Most suggestions for spending more capital to effect savings in the long run are viewed askance, possibly because the way things are there is every incentive to cut down on capital expenditure even if it involves increased maintenance and operating charges. Yet fuel is bound to be progressively more expensive and hard to come by, and in fact it has been authoritatively stated that atomic electricity will become competitive in cost with coal or oil generated power by 1960 because of the increased cost of fuel. Whether the idea still in the experimental stage of importing liquid methane in refrigerated tanks from South America will alter the picture remains to be seen.

Enormous savings can be made in fuel costs in most establishments as the National Industrial Fuel Efficiency Service has proved. A case quoted refers to identical plants in a plywood mill in Canada, where wood waste was burned, and no coal was needed, and in England where coal was being used to burn wood waste. Perhaps the climate is damper here!

However, all sources of heat losses are worth looking into, including tank and pipe insulation, building insulation, exhaust fan losses and boiler efficiency; a little initial extra expenditure can be well worth while.

TOO MANY WORDS

COURSES to facilitate quick readings are very popular in the U.S.A., but so far the idea does not seem to have caught on over here. It has been estimated that the average executive needs to read some 100,000 words per day to keep up with the times and this is quite a formidable task at an average reading speed of 300-500 words per minute. With training this rate can be increased to 900 words per minute, but to absorb 700 words per minute is considered pretty good.

One of the difficulties with the technique is to prove experimentally that time is actually saved in their work by those who have been through the training course. Not many executives are willing to have their normal day's work subjected to time study for research purposes! There is also evidence that the maximum speeds obtained after the course has ended tend to fall off somewhat.

The average reader should have got to the end of—and understood—this paragraph in about half-a-minute, and the fast reader in 15 seconds. How did you make out?

A Survey of AIR TREATMENT SYSTEMS in use in the Metal-Finishing Industries

by LEO WALTER, A.M.I.H.V.E., A.M.I.Plant.E.

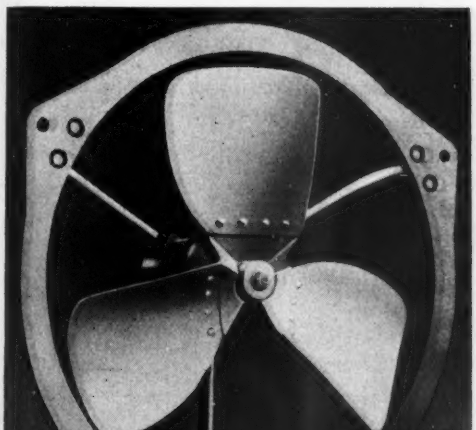
(*Continued from page 70, February, 1957*)

IT will be appreciated that the design, supply and installation of special air treatment systems comes within the field of ventilation contractors, and that this short series of articles is only intended as a guide to potential users, or to users of an air treatment plant who wish to improve an unsatisfactory existing installation. In discussions with ventilation and air treatment experts the user should be in a position not only to follow their suggestions but also to express his requirements clearly and decisively.

Types of Circulating Fan

The three main types of fan are the propeller, axial flow and centrifugal types. Propeller fans move the air by a screwing action similar to that of a ship's propeller (Fig. 1). They are often supplied with a ring frame, the motor being supported by three or four arms. Axial fans are similar in appearance, but the blades are of aerofoil section and are quieter in operation. Standard sizes range from 12 to 48 in. in diameter, moving air volumes of from 300 to 40,000 cu. ft. per min.

Fig. 1.—A typical propeller fan. (Courtesy of Keith Blackman Ltd., London.)



"Spiratube" in use in a polishing and buffing shop making possible the continuous exhausting of air from the neighbourhood of a travelling polishing head. (Photograph by courtesy of Flexible Ducting Ltd., Glasgow.)

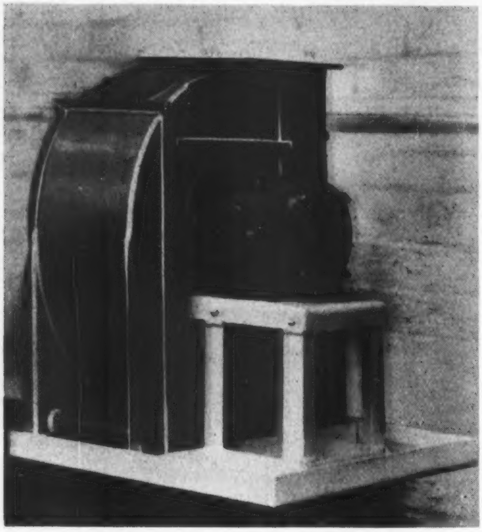
There are numerous makes and sizes of centrifugal fan (Fig. 2) each of which may be classified under three main types. These include types to be used for supplying large volumes of air against relatively low resistances. The information required for the proper selection of a ventilating fan is the volume of air which is to be moved, the resistance or static head against which the air is to be supplied and the resistance required against fumes, gases, vapours, etc.

For fume removal the construction of these systems involves the use of special materials for fans, ductwork and hoods. In Fig. 3 a large fan is illustrated, having an impeller of 38 in. dia., which is capable of handling 24,000 cu. ft. of air per min. The type shown is entirely made from P.V.C. for use in fume removal systems.

In some metal finishing operations the volume of vapour or fume arising from a process does not justify the installation of special plant for removal, and natural ventilation may well suffice. In other cases in the interests of health and efficiency of

Fig. 2 (right).—A range of centrifugal fans fabricated in P.V.C. for removal of corrosive fumes. (Courtesy of Keith Blackman Ltd.)

Fig. 3 (below).—Type of Centrifugal fan. (Courtesy of A. E. Griffiths (Smethwick) Ltd.)



employees, installation of fume removal plants is necessary and may be compulsory under the Factory Act of 1937 and under by-laws. There are borderline cases, of course, but where in doubt the requirements for workers' comfort and health should be the over-riding factor.

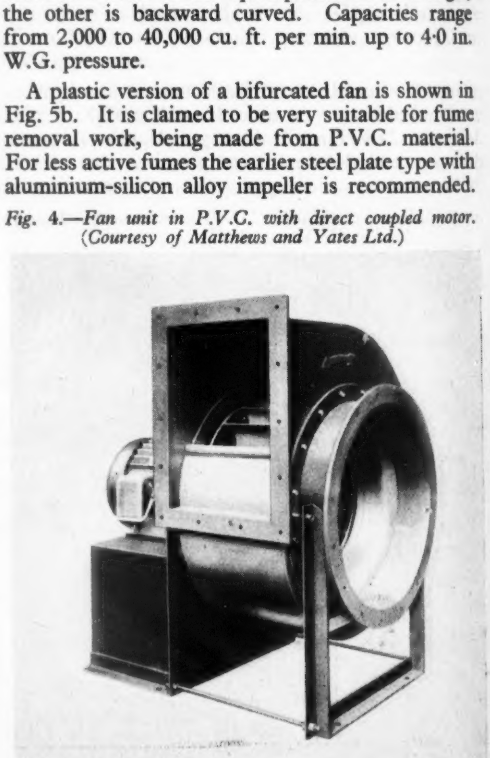
Design of Fume Removal Systems

The design of a fume removal system has to provide extraction which will deal with the maximum possible volume, without putting into operation any excess capacity. An undersized fume extraction system is bad because it does not eliminate all existing fumes and vapours, while an oversized system adds unnecessarily to the cost of heating and ventilating. To entrust the layout design to a reputable experienced firm is a wise precaution on the part of a potential user.

Examples of processes in metal finishing and allied operations requiring fume extraction plant are those involving galvanizing, pickling, acid dipping, spray painting, and vapours of such solvents as trichlorethylene and others. The handling of corrosive fumes and/or of inflammable or explosive vapours may call for the use of special metals or of non-metallic acid-and corrosion-proof materials for fans and ductwork. For example, the Turbo-Cyclone fan shown in Fig. 4 is made from P.V.C. (polyvinyl chloride) material which is resistant to the influence of fumes and moist gases at temperatures not exceeding 140° F. All metal parts are claimed to be isolated and an 18-blade multivane impeller is used. The latter incorporates a mild steel centre hub which is P.V.C. covered. Totally enclosed motors ensure undisturbed operation. Fig. 5a illustrates a P.V.C. fan for fume removal, for which two impeller types are available. One is forward curved of the open paddle-blade design; the other is backward curved. Capacities range from 2,000 to 40,000 cu. ft. per min. up to 4·0 in. W.G. pressure.

A plastic version of a bifurcated fan is shown in Fig. 5b. It is claimed to be very suitable for fume removal work, being made from P.V.C. material. For less active fumes the earlier steel plate type with aluminium-silicon alloy impeller is recommended.

Fig. 4.—Fan unit in P.V.C. with direct coupled motor. (Courtesy of Matthews and Yates Ltd.)



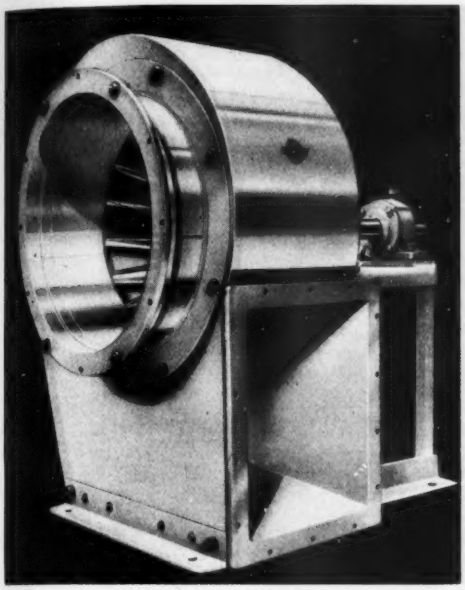


Fig. 5a (above).—Fan in P.V.C. for fume removal available with two types of impeller. (Courtesy of Keith Blackman Ltd.)

Fig. 5b (right).—Bifurcated fan in P.V.C. (Courtesy of Keith Blackman Ltd.)

It comprises a bifurcated or divided casing which accommodates a totally enclosed motor. The P.V.C. range is of virtually the same design but constructed in solid P.V.C. material. Fitted directly into the ductwork, the range is from 10 to 19 in. diameter. For higher duties "Tornado" fans of the centrifugal type constructed in P.V.C. are available from the same makers.

Figs. 6a and b illustrate ducting, made entirely from P.V.C. material, as widely used in systems for removal of acid fumes and moist gases from chemical processing operations, and in metal finishing plants. The Fan Manufacturers' Association (see bibliography) recommends that size and consequently capital costs of any fume removal plant be kept at a minimum. This involves a careful preliminary investigation of the plant itself in order to consider process alteration with a view

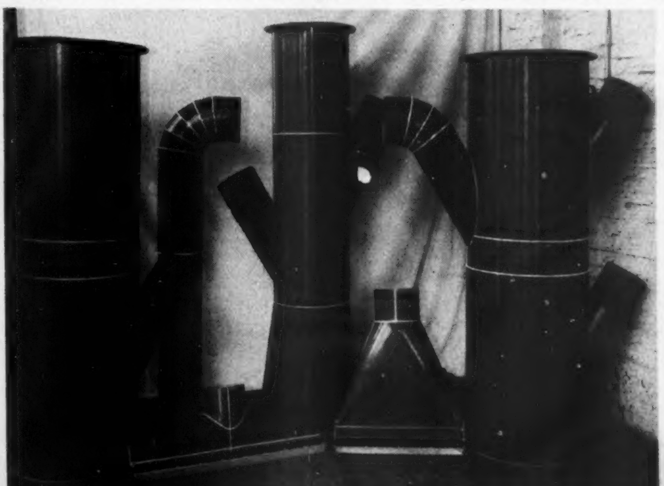


Fig. 6a.—Examples of ducting fabricated in P.V.C. (Courtesy of A. E. Griffiths (Smethwick) Ltd.)

Fig. 6b.—Part of an exhaust duct system fabricated in P.V.C. (Courtesy of A. E. Griffiths (Smethwick) Ltd.)

to minimizing emission of fumes, *i.e.* reduction of volume to be exhausted. In general, it is advisable to design hoods for enclosing tanks, vats, machines and the like, but some operations do not lend themselves to this.

For example, for galvanizing, pickling or impregnating tanks, overhead, side or floor hoods may have to be used, according to whether the fumes are lighter or heavier than air. A curtain of fresh air between plant operator and source of fume emission is sometimes necessary. Methods of discharge and disposal of fumes require exact investigation. In some instances fumes can be discharged directly to atmosphere. Some fumes, however, tend to produce particle deposits, or they condense into acid liquors. These require the inclusion of interceptors in the fume extraction system.

Detection and Elimination of Hazardous Vapours

Vapours in metal finishing departments can be either unpleasant, or obnoxious and dangerous. In some instances they can be detected by somebody's nose in good time, and precautions can be taken for improved ventilation until the cause of the trouble has been found and remedied.

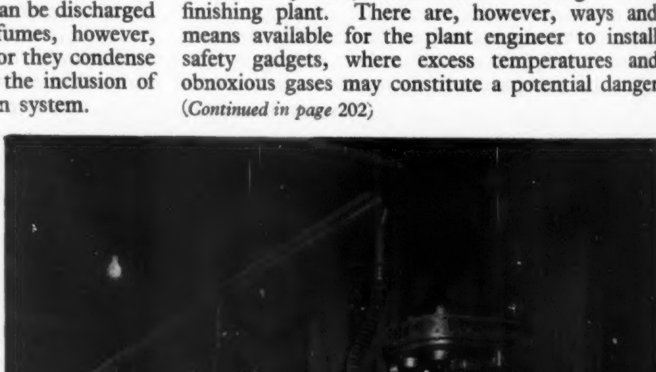
There are now leak detectors available for obnoxious gases, which detect certain dangerous vapours and automatically sound an alarm. For example, in an American plant a vapour detection alarm system installed in a four-storey stillhouse works in conjunction with a closed ventilation system. A gas-analyzing instrument constantly checks the vapour content of air samples flowing through a detector cell containing a heated platinum filament and a second standard filament. Air samples are drawn through the analyzer from eight locations and should the presence of undesirable gases be detected pilot lights indicate the dangerous area and the alarm is sounded.

An additional protective measure is a mercury switch arrangement for the two main vent outlets on the roof from the ventilation system. If the temperature of vapour being vented should reach 140° F, an alarm is sounded and investigation is started to find the cause of the excess temperature.

Interesting as the above system—claimed to be the first of its kind—may be, the cost of installation can scarcely be justified for the average metal finishing plant. There are, however, ways and means available for the plant engineer to install safety gadgets, where excess temperatures and obnoxious gases may constitute a potential danger

(*Continued in page* 202)

Fig. 7.—"Spiratube" in use in a solvent recovery system. The ducting allows the lids of the mixers to be raised for emptying without having to be disconnected. (Courtesy Flexible Ducting Ltd.)



VITREOUS ENAMELLING OF *ALUMINIUM*

New Developments Discussed at 13th Annual Refresher Course in Vitreous Enamelling organized by FERRO ENAMELS LTD.

EARLY this month, the thirteenth two-day Refresher Course held under the auspices of Ferro Enamels Ltd., Wombourn, was held at Wolverhampton Technical College. This course was attended by representatives from over fifty companies throughout the country who use enamels including one from South Africa.

Mr. S. W. Vickery, managing director of Ferro Enamels Ltd., addressed the representatives at the opening session, and lectures were given throughout the first day by Ferro Enamel engineers, largely on the theme of vitreous enamels for aluminium, but including a discussion of vitreous enamel requirements for architectural service.

The main guest lecturer on the second day was Mr. Edward Mackasek, on a visit from the United States, where he recently retired from the position of Managing Director of the Porcelain Enamel Institute. He spoke on the development of architectural porcelain enamel in the U.S.A., and showed illustrations of some architectural installations.

In view of the very great topical interest in the subject of the vitreous enamelling of aluminium extracts are given below from two of the papers on the subject which were delivered during the Course.

MILLING ALUMINIUM ENAMELS

By N. G. GUY

The enamelling of aluminium is a comparatively new departure, and, as might be expected with a different base material, completely new enamels and unusual techniques have had to be developed. The difference between the preparation of the enamel slips for steel and aluminium is very marked and before going into the mill additions used it may be profitable to discuss briefly the reasons for these differences.

Aluminium is readily attacked by alkalis even in low concentrations, whereas steel is relatively unaffected by anything but fairly strong acid solutions.

Due to the high thermal expansion of aluminium it has been necessary to produce frits of high expansion which incidentally are high in alkalis, as a means of lowering the compressive stress in the enamel.

When these enamels are finely ground they yield a mill liquor which has a high alkalinity.

Another difficulty when using a standard mill addition is that the presence of a refractory material such as clay in the enamel increases the maturing temperature and the result is a poor immature enamel at the required firing temperature. It is therefore obvious that special mill additions as well as special frits are required for the successful enamelling of aluminium.

All aluminium enamels must be finely ground, as although the enamels are soft the coat applied is very thin and the particles themselves have no flow during firing.

Furthermore, with the high thermal expansion of the base material, there is a tendency to cracking of the enamel surface before fusion has taken place, resulting in tearing or crawling. To overcome the difficulties mentioned it is necessary to add auxiliary fluxes at the mill. These act:—

1. As a buffer to neutralize the high alkalinity of the mill liquor and inhibit metal-alkali reaction.
2. As a flux to promote rapid fusion of the enamel during the early stages of firing and prevent tearing and crawling.

A great deal of research work has gone into the selection of the most suitable auxiliary fluxes for use as mill addition materials in aluminium enamels and tests carried out by various workers have included the use of sodium silicate solution, borax and lead borate, to mention but a few. The results of these three were as follows:—

1. Sodium silicate was unsatisfactory added as a single flux giving a cement-like coating restraining the enamel expansion in firing, resulting in cracking and tearing of the fired enamel surface. This material is also difficult to handle.
2. Borax increased the high alkali solubility of the frit giving poor drying and firing.
3. Lead borate, while low fusing had no buffering effect on the enamel slip and consequently did not prevent alkali/metal reaction.

The materials widely used and incidentally now recommended by Ferro Corporation are sodium metasilicate and boric acid in equal proportions in easy-to-mix powder form. To assist in preventing metal/alkali reactions it is recommended that certain grades of aluminium receive a chromate

treatment to form a passive or inactive oxide layer on the metal surface.

The greater part of the tests carried out by Ferro Enamels Ltd. at Wombourne have been with lead enamels milled with the following mill addition:—

Frit	100 lb.
Sodium metasilicate	3 lb.
Boric acid	3 lb.
Water	45 lb.

Fineness of grinding 0·1–0·2 gm. on 325 mesh from 50 c.c. sample.

Specific Gravity adjusted 2·0 to 2·04.

Fineness of grinding is very important and although it is permissible for certain special jobs to increase the sieve residue to 0·5 grams/325/50 the fired surface will not be up to standard, due to the particles of enamel not flowing together, and unless absolutely vital, this increase is not recommended. However, it is not satisfactory to grind finer than 0·1/325/50, as this gives rise to a greater tendency to tearing.

The mill addition quoted above, although it works well, has the disadvantage of a tendency to settle out on standing. This trouble has now been overcome to a large extent though not entirely eliminated. The improvement has been arrived at by a slightly altered mill addition as follows:—

Frit	100 lb.
Sodium metasilicate	2 lb. 8 oz.
Boric acid	2 lb. 8 oz.
Bentonite	8 oz.
Water	50 lb.

Fineness 0·1–0·2/325/50.

It has been found that with the first mill addition after a few days standing the enamel had a 50 per cent. loss of set.

The enamel containing bentonite, however, after 10 days standing had only a 10 per cent. loss of set. Surprisingly enough, the enamel containing bentonite was found to have other slight advantages over the first enamel giving improved fired surface and greater freedom from pinholing.

The adjustment of set of all the enamels is controlled by the amount of water added at the mill. It is not necessary with aluminium enamels to use an entirely different cover coat from ground coat enamel, as is the case with sheet iron enamels. The normal practice is to use the same enamel for ground coat and cover coat but any colouring oxides are added at the mill, 3–5 per cent. as required for the cover coat.

With white enamels a pigment grade of titanium oxide is added up to 12 per cent. in a special frit. Later developments have produced lead-free frits which will take all colours, which was not the case with lead-bearing frits, special different frits being used for reds, white and dark colours.

An added advantage of the new lead-free frits is the ability to give a good one-coat job in most colours, but this depends even more so than with lead enamels upon having a suitable metal base.

Due to the fineness of grinding required, an increase in milling time of up to a 100 per cent. is to be expected, *e.g.* 1 150 lb. mill may take up to 16 hours to arrive at the correct fineness. It is practical, however, to use high density grinding media and some firms use this method with a noticeable improvement in grinding time over normally charged mills.

In the milling of enamels for aluminium, absolute cleanliness is vital, minute pieces of dirt if they do get past the gun will cause severe surface defects due to the thin coats applied and the lack of flow of the enamel.

Due to the fineness of grinding necessary the enamel is subject to hydrolytic attack which produces small aggregates in the enamel, this increases the tendency to tearing. The aggregates usually appear from two to six weeks after the enamel is milled and if this trouble is present it also manifests itself in the dull appearance of the fired enamel. This defect is a sure sign of excessive ageing. The enamel can sometimes be reconditioned by returning it to the mill and regrinding for a short period.

Metal Preparation

Any article which has been drawn or fabricated using a wax or tallow type of lubricant should have the remains of these materials removed by immersing the ware in a solvent/vapour degreaser. These drawing compounds are difficult to remove by other methods and must be completely removed before proceeding with the next step.

The cleaner solution consists of sulphuric acid and a commercial detergent in the following percentage proportions:—

Detergent	0·25
H_2SO_4 (conc.)	6·0
Water	93·75

This cleaning bath is used at room temperature and the immersion time is 15 minutes.

A household detergent such as Dreft has been found to give quite satisfactory results in this cleaning bath.

After the 15-minute immersion the ware is removed from the bath, carefully spray rinsed with cold water and allowed to drain and dry. The occurrence of water break on the cleaned metal surface need not necessarily be due to grease. It may be from the high polish of the surface.

If the type of aluminium used is of one of the purer grades, it is only necessary to prefire the articles before enamelling. The prefiring has the double advantage of stress relieving the ware, thus

reducing any tendency to strain line, and fixing any loose oxide layer that may be present on the surface.

Prefiring is usually done at a slightly lower temperature than that at which the pieces will be finally processed and for approximately 75 per cent. of the time.

If the aluminium being used is an alloy fairly high in other metals the procedure is slightly different. After the cleaning bath and before prefiring the ware is immersed in a pickling or chromating solution as follows:—

Chromic sulphate	...	0·241 per cent.
Pot. dichromate ...	...	17·7 „ „
Sodium hydroxide	...	9·5 „ „
Water	...	to 100 „ „

This solution is used at 49° C and the immersion time for sheet aluminium is 4 minutes.

For cast alloys the immersion time may be increased up to 7 minutes but over-chromating must be avoided. The ware is removed from the bath after the required time and spray rinsed with cold water to remove any visible chromate remaining.

After draining and drying the ware is prefired as before.

After prefiring any loose surface oxide on the ware should be scrubbed off, rinsed and dried. The articles are then ready for enamelling.

APPLICATION OF VITREOUS ENAMELS ON ALUMINIUM

by A. H. SYMONDS

In the enamelling of aluminium as with enamelling of iron, certain restrictions are placed on the type of metal which gives easy working and satisfactory results when enamelled.

Aluminium products are available in many alloys, alloyed with silicon, copper, magnesium and so on, and these alloys have been developed for specific purposes to give strength, ductility and many other useful qualities. Articles may also be fabricated out of sheet or wrought, extrusions or in very many different cast forms. Not all these forms are suitable for enamelling.

It is possible to enamel a fairly wide variety of aluminium sheet but the best results are obtained from standard quality sheets of a fairly high degree of purity and a high percentage of aluminium sheets in use are 99 per cent. pure aluminium.

The types of sheet that have given the best results are S.1C and N.S.3 (B.S.S. 1470).

Other compositions may be enamelled and here it is necessary to know the composition and then to carry out enamelling trials. These sheets may be obtained fully annealed, quarter hard, half hard, threequarters hard and hard. Probably quarter to half hard is most suitable for enamelling.

Cast aluminium presents many more variables apart from composition. There are many forms of die-cast aluminium and no success has been found yet in enamelling pressure die castings due to the sub-surface laminations caused by gas secretions. These cause bulges of metal to rise at the surface when the metal is heated, and render the surface quite unsuitable.

Gravity castings either in sand or permanent mould castings may be suitable, the general composition of cast aluminium which is suitable for enamelling should be such that copper is not in excess of 0·25 per cent., magnesium 2·5 per cent. and silicon 10 per cent.

Spraying of Enamel

The enamel consistency should be adjusted so that with a fine, easily controlled spray the enamel readily gives a wet surface. This, of course, must be controlled so that there is no tendency to run on vertical surfaces. This condition can be obtained with a specific gravity of 1·8 to 2·2 depending on the type of mill addition used and the amount of titania. The enamel is all sieved through an 80 mesh sieve before spraying. If enamel is left standing a week or two it may be found that some fine lumps have developed; these should be broken up by resieving.

Spray guns need to be kept in first-class condition, and fine nozzles and needles, as would be used for paint spraying, are most suitable. At the fusing temperatures employed, the enamel has little flow in the fire, and, therefore, it is necessary to spray a smooth surface in order to get a smooth surface when fired.

Cleanliness

In aluminium enamelling air-borne dust can cause very serious defects. The enamel is much more prone to contamination troubles than are ferrous enamels, and, in one respect especially, trouble may be experienced; that is contamination with sheet and cast iron enamels. There are few shops where there is not a good deal of enamel dust about, and this may cause serious detriment.

Application weight varies slightly with different enamels. For instance, A1·4, A1·5, and 7 are applied at 18 gm. per sq. ft. one side, which results in a fired coat thickness of ·003 in. A1·8 may be

applied as heavy as 36 gm. per sq. ft. on one side giving a fired thickness of ·005 in. Application weights may have to be varied to suit the particular application.

Not all work is obtained satisfactorily in one coat, and due to the higher cost of the enamel frit some commercial producers of enamelled aluminium make up a specific first-coat or ground-coat enamel. This is simply made from spray booth scrapings, and gives a suitable enamel surface over which the finish coating smooths down easily to give a high quality finish.

In some cases, depending on the thickness of the metal used, it may be necessary to coat the back of the thinner sheet aluminium with enamel. Aluminium has a very high co efficient of expansion and, while the enamels used have also a correspondingly higher expansion, the difference of expansion between the metal and the glass can distort the sheet. A backing coat will cure this satisfactorily.

In handling aluminium prior to spraying care should be taken not to handle the faces to be enamelled.

Spraying Equipment

Consideration should be given to the type and condition of the spray booths used. Factory regulations require an air movement at the face of the booth of 100 cu. ft. per min. Normally the fan capacity would be planned to give an air movement at the face of 150 cu. ft. per min. which would give a good safety factor.

When the spray booths are in use, regular cleaning is required to maintain them at their best condition, and recovery of enamel overspray will be important. Spray guns require to be maintained in good condition. Such things as air leaking in fluid lines due to badly seated nozzles, worn needles and fluid tips, air valve not operating prior to fluid valve, all require immediate attention. If pressure containers are used they should be in good condition and will require air-operated agitators to prevent settling out. Air free from oil and water is essential.

Dipping

Aluminium enamel may be readily applied by dipping although there is not so much emphasis on dipping as there would be with sheet iron enamels, and generally, spraying is found to be more satisfactory especially where only one side needs coating.

The exceptions are, where it is impossible to get to the surfaces to be coated with a spray gun. Here, the articles can either be dipped in the enamel or may be filled and drained. The enamel may be thinned by adding water. A temporary increase in set can be gained by the cautious addition of phosphoric acid to the slip.

Drying

Many shops engaged in aluminium enamel do not completely dry the enamel at all. Satisfactory results have been obtained by firing the enamel wet. The best condition is the critical period when the last moisture is leaving the surface. Obviously such a method cannot be used in batch production, although it is carefully calculated in continuous furnace production so that the ware enters the furnace at this stage. It is quite possible that a controlled humidifier may be useful rather than a dryer.

Brushing

The nature of the biscuit formed by dried aluminium enamel slip is so hard and tenacious that it is very difficult to brush surplus enamel away. Due to thickness of the normal coating, there should be the little necessity for brushing. Where it is essential, wet wiping immediately after spraying is likely to be successful, or, alternatively, masking tape may be used.

Evaluation and Control of Quality of Porcelain Enamel on Aluminium

A number of tests have been worked out with good results for enamelled aluminium. The standard acid and alkali resistances are satisfactory for testing resistance to solubility. The normal deformation test for bond and adherence can be used and this gives exceptionally good results compared with enamelled steel. Where the necessary equipment exists a tension test can be made on special right angle strips.

A special test has, however, been designed for use with enamel coatings on aluminium. This is known as a spall test and the purpose is to test for retention of adherence at cut or broken edges to simulate conditions where enamel ware may be exposed to weather conditions or high humidity. The sample for testing has the edges exposed by stoning or cutting and is then immersed in a 5 per cent. solution of ammonium chloride, freshly prepared solution at room temperature. The sample is left in the solution for 24 hours and then examined. If there is no spalling to bright metal areas the sample is left in solution for another 96 hours. Failure is usually either very extensive or negligible if correct conditions have been maintained throughout. Exceptionally high resistance to this spall test is usual.

The Past, Present and Future Developments of VITREOUS ENAMEL AS A FINISH

by T. J. MacARTHUR*

A Paper presented to the Annual Conference of the Institute of Vitreous Enamellers, Brighton, October, 1956

THE purpose of this paper is to consider vitreous, or porcelain enamel; as a finish, how it has developed as an industrial finish, its present position in regard to other finishes, and to examine in general possible future trends.

It is well known that vitreous or porcelain enamelling as a form of decoration for metals has been in existence for more than a thousand years, but its use as an industrial finish for iron and steel is comparatively new.

The industrial use of vitreous enamel has grown immensely during the past 100 years, but the greatest expansion has occurred during the past twenty-five or thirty years. This tremendous growth of what was previously a small industry, was brought about by the development of wet-process enamelling on cast iron, particularly by the adoption of spray-gun application methods, and by the requirements of the domestic-appliance manufacturers in their need for a durable and easily cleaned finish. As an example of the rate of expansion of the enamelling industry, present production of enamelling plants in the United States of America is 3½ times as great as in 1940, while in the U.K. a very large programme of new plant installations and plant extensions has been carried out.

This steeply rising rate follows the general rate of expansion of the domestic-appliance industry, but it is important to keep in mind also the extended use of enamel as a finish for *new* products, among the most notable of these being pressed-steel sinks and baths, hot-water storage tanks and architectural panels.

This enormous growth in the use of enamel would indicate that during the last twenty-five years the industry has maintained a steady improvement in both methods and materials.

It is true to say that vitreous enamel is the most permanent decorative finish known for iron and steel. Its decorative qualities are of major importance, but in the domestic appliance industry the permanence of the finish is all important. Organic coatings may be applied to some cooker components, but so far no such coating is known which will give the same life and high resistance to abrasion, heat and chemical attack as vitreous enamel.

However, this advantage of permanence is not always necessary in choosing a finish for an article, and many organic coatings have been developed in recent years that will give a moderate degree of resistance to corrosion of iron and steel. In many cases these finishes offer a cost advantage, and although so far they offer no serious threat of competition where a high duty finish is required, they defend certain markets against vitreous enamel on appliances where a shorter life of finish may be tolerated. As for example, washing-machine exteriors, refrigerators, and kitchen cabinets.

Although the overall picture in the enamelling industry has been of vast expansion, it is acknowledged that vitreous enamelled iron and steel has lost ground in certain instances to other materials.

Use of Alternative Materials

In the refrigeration industry laminated plastic inner door linings and aluminium hardware have largely replaced enamelled steel.

Laminated plastics have also captured almost the whole of the conventional enamelled steel table-top market. Another example is the competition which enamelled steel holloware is experiencing from stainless steel, aluminium and moulded plastics.

There are exceptions concerning the cases quoted. An interesting example is the large scale revival of cast iron holloware. Large quantities of enamelled cast-iron holloware are being produced in Europe and exported. The successful marketing of this ware is entirely due to artistic designing in both shape and colour.

The various articles are designed by specialists of world fame and they fully exploit the attractive characteristics of colourful vitreous enamel. This is a specific case of pleasing, eye-catching finish selling the article.

In a more general sense, sections of the steel holloware industry have fought competition with new designs, better colour values, improved quality of enamelling and adoption of heavier gauge steel. Companies who have followed this policy of improving the product have managed to retain a healthy share of business.

* *Stewart and Gray Ltd.*

A similar approach would recover some of the business lost to laminated-plastic tops. The old-fashioned flanged table top had many faults. It was usually finished with unsightly black flanges, it was subject to excessive surface distortion during manufacture, and was noisy in use. Some of these faults were inherent in the materials used, but the methods of manufacture and design exaggerated them. An attractive table top can be produced having none of these disadvantages. Resonance and wavyness of surface can both be overcome by bonding enamelled light gauge steel to a firm base, such as hardboard or chip-board. Edges can be protected by a trim of light alloy, stainless steel or plastic, and this rim can be used to complement the colour employed on the surface of the top.

Design and Colour of Vitreous-Enamelled Ware

These instances of successful operation in the face of competition illustrate the desirability of using good design incorporating complementary materials and fully exploiting the attractive texture and splendid colour range of vitreous enamel.

The limited colour range available on major domestic appliances is obviously due to the production difficulties and high costs involved in introducing multi-colour application into highly automated plants, but this has led to the modern kitchen presenting a general colour background of white or cream. There is a growing customer-demand for stronger colours in the home, and in the finishing of articles such as sinks, holloware, heating appliances and table tops this demand is being met.

In keeping within the general theme of this subject it may be of interest at this point to consider how some of the more recently developed markets for vitreous enamel finish were opened up. One such development is that of the manufacture of enamelled pressed-steel sinks and baths. Production of this type of sanitary ware first began in the United States during the early 1930's and has continued to expand.

Today several companies in the U.S.A. and England produce enamelled steel sinks and drainers. Some companies in the U.S.A. and one in Sweden are producing one piece steel baths. The development of this market is a classic example of success following sound design and production methods. In many early cases bath tubs were produced from a number of welded sections involving high costs in fabrication and enamelling rejects. Consequently most of these ventures failed.

The most successful manufacturers in this field have for some years produced one-piece deep-drawn bathtubs and sinks—keeping welding to an absolute minimum and providing shapes which can be enamelled with a minimum of trouble.

Another and more recent example is the enamelling of hot-water tanks for domestic heating plant. In the last few years the production of vitreous-enamel-lined hot water tanks has passed through the development and proving stages, and enamelled finish is now accepted on the American market. The costs of development were high. One American company is reported as spending $750,000 on development and design, but this has promoted an enormous new use for vitreous enamel. Some of the technology employed is worth mentioning. One type of tank consists of an outer jacket and inner flue. The inner flue pipe is flanged to form the bottom of the combined tank and heater flue. The two components are enamelled separately and after inserting the flue into the tank they are welded together.

One manufacturer has developed fully automatic grit blasting for cleaning prior to enamelling. This machine handles 220 tank shells per hour, the sizes being from 12-in. diameter and 20 in. long to 20-in. diameter and 65 in. long.

Extensions in the use of vitreous enamel cannot be discussed today without touching upon its use in building construction. During the past four years this outlet for vitreous enamelling has developed rapidly, due to the popularity of curtain-wall building. This type of building incorporates the need for thin outer skins which provide both protection and insulation.

The background to this development began some thirty years ago, when jobbing enamellers in the U.S.A. began to supply facing panels for shop fronts and filling stations. This business developed slowly, but the enamellers concerned gradually improved their products and service. In several cases the enamelling companies trained their own teams of erectors and undertook to supply and fit the complete job. This field was highly specialized and much valuable experience was gained by the companies engaged in it on quality standards, production methods and the correct use of colour on large areas of building faces.

This use of vitreous-enamelled steel was not adopted in Europe, probably because the last war interrupted such developments at a time when some enamellers were becoming interested, and the years immediately following the war were a period of prosperous trading with consequent shortages of materials and plant capacity.

From this background and the experience gained, American enamellers were well equipped to enter the curtain-wall in-filling panel business and vitreous-enamelled steel has become an important material among the many available.

Architectural requirements are for durability, strength and colour, and these are met more fully by vitreous-enamelled steel than any other material. This market for vitreous-enamel finish must not be underestimated for potential sales or for the very high quality standards necessary.

This review of the development of uses for vitreous enamel as a finish is necessarily limited in scope, but it does give an indication of the need for continued technical work for the providing of materials, methods of application, design and market development.

Points of Criticism of Vitreous Enamel

The two main points of criticism which are aimed at vitreous enamel are that it will chip, and because the finish involves high temperature firing, components are subject to distortion. Failure by chipping is a characteristic of a glass coating, and must be weighed in the balance against many advantages. In the case of assembled appliances, most chipping occurs during transportation, and a great deal of research has gone into an investigation of this problem. Correct design of packing and of the appliance in order to avoid excessive strain during movement in transit can keep the risk of damage through chipping to reasonable limits.

The domestic-appliance industry takes up more than half of the enamelling industry's volume of production, and if vitreous enamel is to continue as a standard finish for domestic appliances, work must be carried out on an investigation to reduce and eventually eliminate distortion of component parts during the enamelling process.

Modern production techniques call for a smooth flow of correct components to the assembly lines, and time cannot be allowed for special treatment of a particular component.

The risk of distortion occurring continually on a particular component can be avoided by co-operation between those people responsible for design and those with processing experience, but we must, as an industry, progress towards developing techniques which will give the designer greater choice in shape and gauge of metal employed.

Improved Enamelling Technology

Enamelling technology has improved at a high rate during the past ten years, the greatest single advance being the introduction of lower temperature, highly opaque titanium cover-coat enamels. These enamels have greatly reduced thickness of application, and one has only to remember the enamel coatings applied to sheet steel twenty years ago to realise how necessary was this advancement to the successful production of light-gauge sheet steel cookers.

Research must continue to keep enamels and the engineering of application methods in step with the rapid technical advancements of other branches of industry.

Research and development work are both costly, but it is vital that they continue. An industry that does not allow for adequate research and development costs in arriving at selling prices is jeopardizing its future.

A typical industrial application of vitreous enamel is this cast iron machine base weighing approximately 2 cwt.

In what direction should the industry look in order to improve its technique?

The manufacturers of domestic appliances and architectural panels would greatly benefit from the development of lower firing enamels for sheet steel.

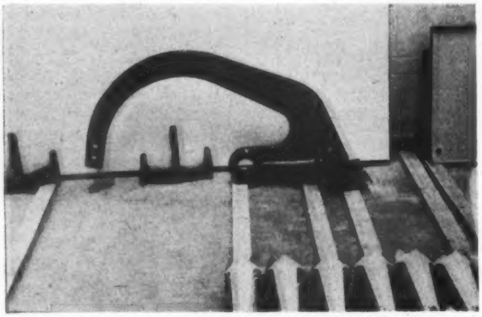
Enamels firing within the temperature range of 700° to 740° C and retaining reasonable acid-resistance would open up the enamelling of larger panels with greatly reduced risk of distortion.

One-coat direct-to-steel enamels have been used on a limited scale, and so far call for special steels which are either in short supply or unobtainable in this country. It is possible that the future will see the development of enamels of this type for non-premium steel, but this would not bring benefits without troubles.

The experience of companies engaged in the enamelling of aluminium sheet with thin coatings is that a very high standard of sheet surface is required, as a small scratch is greatly amplified by the thin finishing coat of enamel.

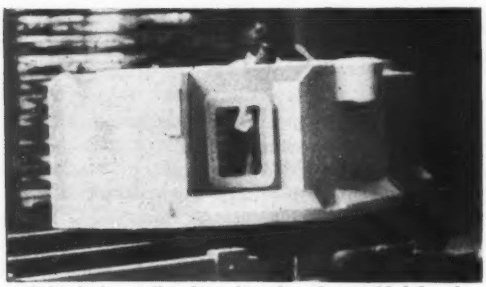
Methods of Work Handling

Along with the further development of improved enamels the industry must keep pace with developments in methods of handling work in production. This is particularly necessary for those people operating large plants producing standard pieces in large volume. The introduction of the continuous furnace in this type of plant is now commonplace. The adoption of automatic dipping and electrostatic spraying would appear to be just as important in this type of plant.

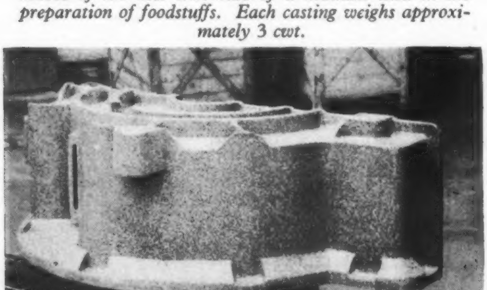


A particularly significant industrial application of vitreous enamel has been this cast iron stirrer arm with renewable end paddles used in the chemical industry for the agitation of highly corrosive chloride compounds. The best performance obtainable by other coatings before renewal in this environment was two days. The coating of highly acid-resistant vitreous enamel now in use on this component has been in service for nine months without renewal.

A large proportion of the enamelling industry is concerned with processing on a jobbing basis, and if those enamelling plants specializing in sign work are included, the jobbing enamelling section is second in volume only to the domestic appliance plants. The true jobbing enameller has a very special place in the industry. It is the extremely varied nature of the jobber's throughput that gives him a wide experience and places him in a strong position to advise on and encourage new ideas in the application of vitreous enamels. His branch has often been the proving ground for new applications and finishes for vitreous enamelling which would not have become commonplace had they not been initially proven by the jobber.



A hygienic, easily cleaned surface is provided by the vitreous enamel coating shown here applied to the two halves of the cast iron base of a machine used in the preparation of foodstuffs. Each casting weighs approximately 3 cwt.



In pioneering and developing new applications the jobbing enameller is essentially the pioneer. He exists by extending his services to encompass new products. The jobbing section of the enamelling industry mainly serves the small manufacturer and at the moment business is affected badly by the restrictions of sales imposed by the credit squeeze.

Now, more than ever, the jobbing enameller needs to promote new outlets for enamelling, and it may well be that the largest potential market is to be found within industry itself in the application of thin protective coatings to items of plant. To some degree this type of business is growing, but a strong educational programme of technical publicity is required in order to inform engineers and designers of the advantages to be had from vitreous enamel as a protective coating.

Finally, the value of vitreous enamel as a finish should not be underestimated. It is an outstanding material, and it is the responsibility of all engaged in the industry to maintain a record of advancement which has taken place in the past, and ensure by the continued exploration of new fields and improved methods that the industry has a future.

Air Treatment Systems

(*Continued from page* 194)

Prevention of leaks and/or escape of obnoxious gases and vapours is, of course, the best method to ensure healthy working conditions in a plating department. Although the Factory Act and other regulations clearly prescribe ventilation requirements, actual surveys of departments where electrodeposition or spraying is performed may disclose possibilities for reducing the amount of effluent vapour produced. By removing noxious processes to isolated premises it is often possible to obviate the necessity for providing elaborate ventilating systems in the main shop. Out-dated ventilating installations, however, can be extremely costly to operate without providing the desired freedom from pollution of the workshop atmosphere.

(*To be continued*)

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CHROMIUM PLATING OF GUN BARRELS

By R.A.F. HAMMOND, B.S.c., A.R.C.S., F.R.I.C.

This abstract of a paper presented to the Midland Branch of the Institute of Metal Finishing in Birmingham in January, 1957, is supplemented by a description of the only industrial plant carrying out the process in this country.

THE problem of heat dissipation in modern high-performance guns is a serious one. The flame temperature of typical propellants is about 2,000° C and the bore surface has therefore to withstand not only this high temperature but also the effects of high-velocity gases (gas-wash) and the friction and mechanical stresses caused by the passage of the projectile.

Unprotected gun barrels erode rapidly, and some form of protection is therefore required. Many desirable properties, including that of high hardness, high erosion resistance, etc., are possessed by electrodeposited chromium. The basic limitation of chromium is its low ductility which causes it ultimately to crack and flake off.

The improvement in barrel life resulting from chromium plating varies widely according to the type of gun and conditions of fire, but, in small-arms, improvements of 8 to 10 times have been recorded; these figures are lower for larger guns but their cost still makes the application of chromium plating worthwhile, both economically and strategically. The chromium plate must be smooth and adherent throughout the bore, and the thickness must conform to the drawing tolerances of the barrel. True concentricity of the plating is difficult to achieve, particularly in the centre of the barrel.

A relatively thick deposit is desirable but the limit of plating thickness is set by the rifling lands, since excessive thickness may result in the lands being almost entirely chromium without a steel core to give support. In practice a thickness of 0·005 to 0·01 in. on the lands is typical, but due to the relatively poor throwing power, the thickness in the grooves is about two-thirds of this amount.

During plating a central rod electrode (anode) is supported in the bore to give uniform current distribution. This electrode acts as the cathode for electropolishing. Three electroplating processes are possible, *viz.*, "full immersion", "part-immersed, forced-circulation", and "exposed forced-circulation".

Plating Processes

The "full immersion" process, due to the "gas lift" produced by the H_2 and O_2 liberated and also to the thermal convection set up, gives vigorous circulation of the electrolyte. It is a relatively simple process and gives reproducibility of processing conditions and maximum uniformity and control of processing temperatures.

The part-immersed, forced-circulation process was developed by A.R.D.E. for long barrels (18 to 20 ft.) before deep tanks (required for the full-immersion process) were available. The breech end of the barrel is sealed and the lower 6 ft. of the barrel immersed in electrolyte in a small tank, from which the solution is pumped into the breech end of the barrel up which it rises and overflows into a plastic container, attached to the muzzle, from which it returns to the tank.

The exposed, forced-circulation process is similar to the previous process, but uses separate reservoir tanks. This process is to be evaluated at the Establishment, and it is believed it should offer advantages in minimum requirements for special buildings, etc., and in handling of the barrels.

Basic Stages in the Process

These are degreasing (by trichlorethylene vapour or immersion in emulsion cleaner followed by cathodic treatment in alkali), oversizing, anodic polishing, de-smutting, and chromium plating.

In barrels designed for plating, oversizing is mainly effected during manufacture, the final oversizing being done by anodic polishing. A barrel requiring a plating thickness, say of 0·005 in., might be made 0·008 in. oversize leaving 0·001 in. (radial) to be removed by anodic polishing. Barrels already machined to size are oversized entirely by anodic polishing.

Anodic polishing removes work-hardened or shattered surface films left by machining, removes "burrs", etc., from the edges of the lands, and also produces some rounding of the edges of the lands, enabling the brittle chromium better to withstand the shearing forces of the projectile driving band. Vapour-honing can be used as an alternative, but appears to give somewhat lower adhesion of the

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* *Ministry of Supply, Armament Research and Development Establishment. Fort Halstead.*

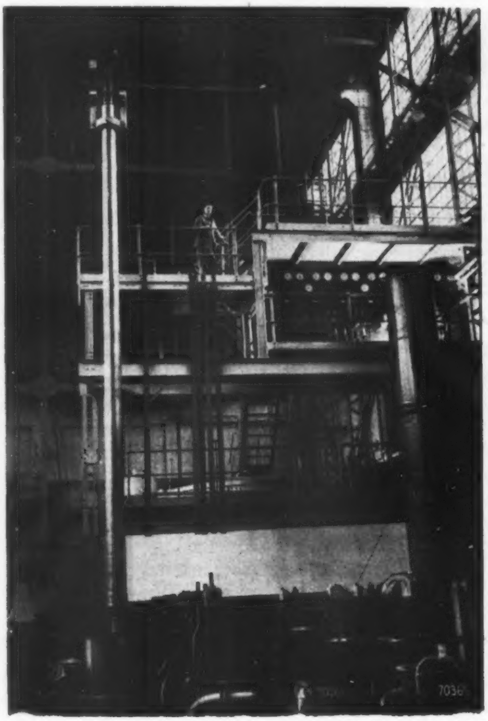


Fig. 1.—6-in. gun barrel with anode and fittings assembled about to be lowered into plating tank at the A.R.D.E. plant.

plating. With this process the barrel must be fully oversized in manufacture.

Two electropolishing solutions have been used, both based on orthophosphoric acid and sulphuric acid, one containing, in addition, chromic acid. This latter solution gives a higher polish, but the other is cheaper and can be treated to remove dissolved iron, and has therefore been adopted. It is operated at a current density of 250 amp. per sq. ft. at 43° C. So many factors influence the efficiency, etc., of anodic polishing that in general, development has been necessarily empirical, but it has been found that although in most barrels the rate of attack is slightly higher in the upper (muzzle) end, for the purpose of calculating the time of polishing a rate of 0·001 in. (radial) in 15 min. is appropriate.

The recommended limit for the iron content of the polishing solution is 30 gm. per 1; regeneration could be effected by a method described by Dr. C. Faust of the Battelle Memorial Institute, but this has not yet been tried.

Atmospheric dilution of the solution is difficult to counter since heating at any temperature practicable in a processing tank fails to eliminate the water from the solution. The Ionic Plating Co. Ltd. have developed a method consisting of withdrawing some of the solution and adding anhydrous P_2O_5 and oleum, but the operation is difficult and somewhat dangerous.

De-smutting, *i.e.*, the removal of "smut" (insoluble carbide residue) after anodic polishing can be effected by anodic treatment in chromic acid or manual scouring with pumice and water. "Smut" must be removed otherwise the adhesion of the chromium deposit is impaired.

The solution used for chromium plating is the conventional one containing 250 gm. per 1 CrO_3, and 2.5 gm. per 1 H_2SO_4; it is operated with gentle agitation at 51° C at a current density of 250 amp. per sq. ft. giving a chromium deposition rate of about 0.001 in. (radial) per hour as measured on the lands of the rifling. During use the solution accumulates iron and trivalent Cr and the combined concentration of these should not be allowed to exceed 10 gm. per 1.

The final cleaning process before plating (a reverse etch in the chromium-plating solution) gives an adhesion of chromium to gun steel exceeding the effective tensile strength of the chromium; although barrels eventually fail by flaking of the deposit this is probably due to brittleness rather than defective adhesion. The production of a smooth deposit is dependent mainly on the quality of the surface finish in the original machining of the bore, but precautions are taken to keep the plating solution free from suspended impurities; these include the supply of clean air to the tanks, continuous filtration of the plating solution, etc.

Radial distribution is determined by the contour of the rifling and by the concentricity and straightness of the anode. Longitudinal distribution, as in the anodic polishing operation, is governed by complex factors, *e.g.*, voltage drop down the anode and along the barrel, presence of dispersed gas bubbles, etc.

When using the full-immersion process for polishing and plating and using a copper-cadmium anode, the tendency is for a slight taper to develop during anodic polishing (larger at the muzzle end) and for the chromium to deposit substantially uniformly. However, with barrels oversized mechanically the resultant taper on the finished barrel is insignificant. It is, in fact, possible by this process to plate plan size barrels requiring full oversizing by anodic polishing, so as to finish parallel within gauging limits.

Treatment of Abnormal Barrels

Barrels which finish tighter than the low limit on bore can only be rectified by lapping in a gun factory. It is therefore most desirable that the plated barrel should finish throughout the bore within the limits allowed. The tolerances allowed to the gun maker and plater respectively are such that with careful work this is normally possible with a straightforward polishing and plating operation.

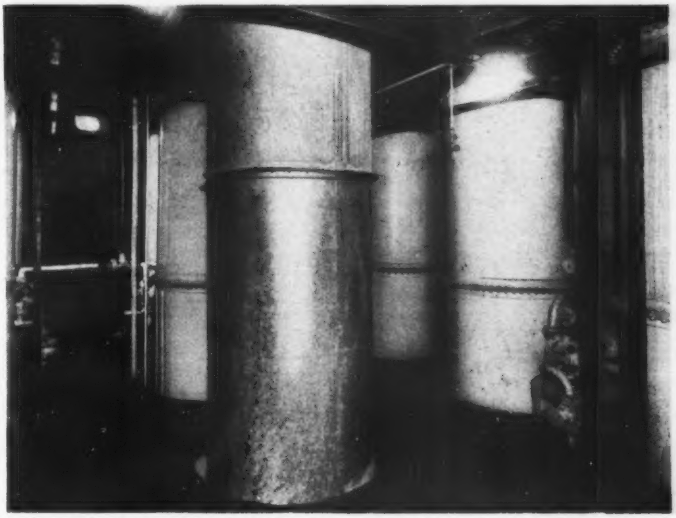


Fig. 2.—One of the intermediate floors in the processing pit at the works of the Ionic Plating Co. Ltd. Note the flange sectional construction of cylindrical tanks. Emergency shower is also provided in case solutions are splashed on to operators.

However, it is possible for a bore, though within limits, to be tapered in the same direction as the slight taper normally produced during plating by the forced-circulation processes using a copper anode. Also, cases have been known in which the bore as received is on tight limits at both ends and slack in the middle. In such cases it may be necessary to anodic polish in steps (stopping off as required to rectify the bore contour).

Barrels which cannot be rectified or on which the plating is defective are stripped by an anodic treatment in 9 per cent. NaOH solution at room temperature using a current density of 20 amp. per sq. ft. and a steel cathode. After stripping, the barrel is given a further brief anodic polish and is then replated.

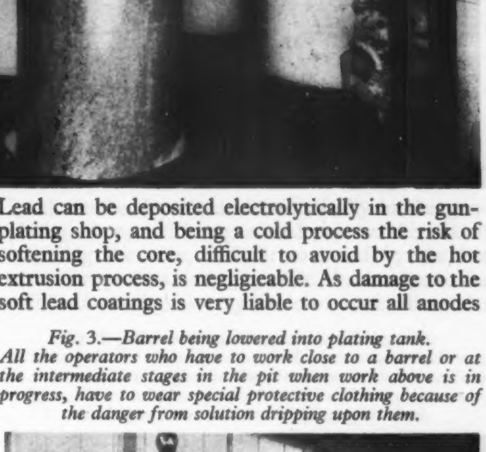
Anodes

These are normally solid rods of hard drawn high-conductivity copper or copper-cadmium alloy, the diameter being about half the calibre of the gun. The alloy is used in British practice because of its higher mechanical properties. The anodes are lead coated either by electrodeposition or by hot extrusion. It is essential for the anodes to be absolutely straight, and notable success in this direction has been achieved by British Insulated Callenders Cables Ltd. in developing methods of manufacture under an M.O.S. development contract for making extrusion-coated anodes.

To polish and plate uniformly in the bore and the chamber of the gun a shaped anode can be used but in practice the tapered deposit produced in the chamber by a parallel anode can be allowed.

The lead or lead-tin coatings on the anodes are required because copper and copper-cadmium are attacked rapidly in chromium plating solutions. Lead can be deposited electrolytically in the gun-plating shop, and being a cold process the risk of softening the core, difficult to avoid by the hot extrusion process, is negligieable. As damage to the soft lead coatings is very liable to occur all anodes

Fig. 3.—Barrel being lowered into plating tank. All the operators who have to work close to a barrel or at the intermediate stages in the pit when work above is in progress, have to wear special protective clothing because of the danger from solution dripping upon them.



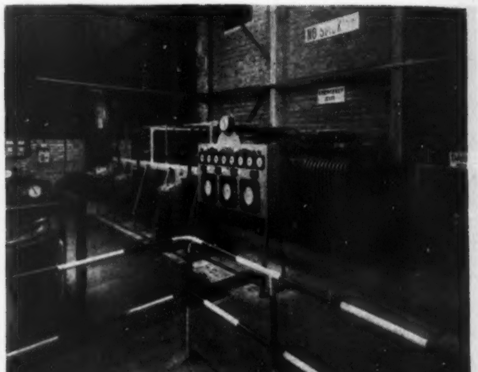


Fig. 4 (left).—Close-up of tank top with a barrel being processed. The weight of the barrel is borne by the steel framework which is independent of the processing tanks. Dial thermometers are provided on each tank to indicate the solution temperature at the surface and at about one-third of the total depth.

Fig. 5 (above).—General view of the d.c. power supply. In the centre of the picture is the control panel which includes, besides ammeters and voltmeters for the various electrical circuits, automatic recording.

are inspected carefully before use and repairs to the coating made as required.

Special fittings are used for the muzzle and breech ends of the gun during processing. The fittings are of mild steel and are adapted to suit the particular design of barrel; they carry bushes of hard P.V.C. which locate the anode in the centre of the bore and insulate it from the cathode. Both fittings are supplied with ports to allow free circulation of the electrolyte.

The gun is supported during transfer and in the processing tanks by a very heavy mild-steel fitting provided with trunnion arms which during processing rest in heavy girder framework at the top of the tank. Current is fed in *via* copper Vee blocks, the whole assembly being capable of carrying up to 10,000 amp.

Of necessity, a portion of the anode is above the solution level and is thus not subjected to cooling by the solution. To this exposed portion an anode

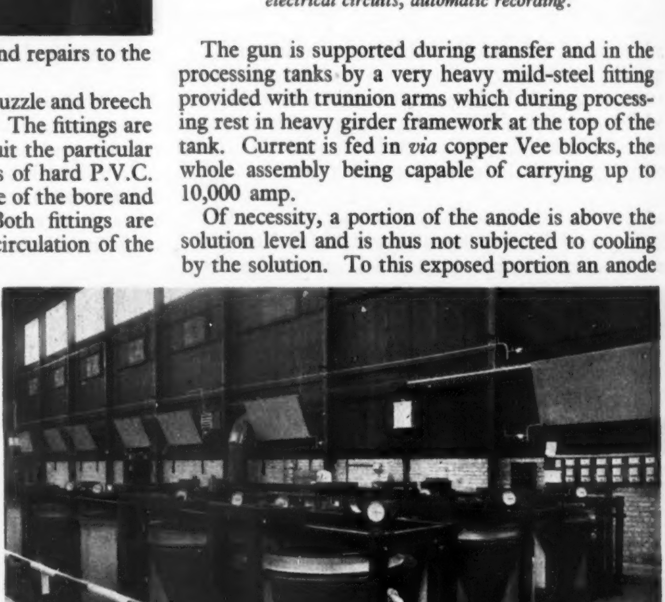


Fig. 6.—View of the tanks showing the lip extraction with the exhaust ducts carried below floor level.

connector in the form of a very heavy copper bush, with a Morse taper bore, is attached.

Owing to the difference in the coefficient of expansion of copper and steel an anode fixed rigidly at the breech and muzzle ends, would flex on warming up from the ambient to the operating temperature. It is therefore necessary to arrange either that one end of the anode should be free to move longitudinally relative to the barrel or to make provision for applying a positive tension to the anode. The method used in practice by A.R.D.E. is to apply tension to the anode partly to accommodate expansion, but also to counter the instantaneous flexure of the anode (anode "kick") which occurs when a heavy current is suddenly applied. For the larger barrels tension is applied to the anode by an expanding screw device clamped to the anode and operating on roller thrust bearings. The device is expanded by tommy bars during the warming up of the gun. Although small barrels can be processed by standard plating equipment for treating large barrels the special facilities required, *e.g.*, a high building equipped with cranes, deep tanks and pits, and a large-capacity source of d.c., involve high capital costs. However, provided that plant is kept fully engaged, barrels can be chromium plated at a trifling cost compared with their initial cost of manufacture.

* * *

The only industrial plant in this country for chromium plating of large gun barrels, as described in the paper by Mr. R. A. F. Hammond, is at the Dudley Works of the Ionic Plating Co. Ltd., by courtesy of whom Figs. 2-7 and the following description of their plant is published.

The plant is so designed as to be capable of plating barrels of various sizes in production quantities, by the full immersion process. All the work is carried out in one large bay with sufficient space for barrel storage, inspection before and after plating, all the processing tanks, and electrical and other ancillary equipment.

The tanks themselves are all accommodated in two pits. The small pit accommodates one row of vats for plating the smallest sizes of barrels; larger sizes of barrels are processed in deep cylindrical tanks standing in a large rectangular pit so that only the top 3 ft. are above the normal shop floor level. The space between the tanks is covered with iron gridwork and similar grid floors are provided at three other levels in the pit to accommodate the ancillary equipment such as pumps, and to give access to the tanks and the lower ends of the barrels during anode assembly.

Vats are provided with lip extraction and the exhaust ducts are taken down below the iron gridwork so that only the main trunks and fans appear above floor level. Provision is made for the automatic recording of the temperature of the chromium plating and electropolishing solutions. The various processing tanks are fed by separate rectifier banks but the individual banks may be coupled together on individual vats to allow for the plating of the largest barrels. In this way flexibility has been achieved without increasing the cost and space of electrical supplies unduly. The movement of the barrels throughout the shop is achieved by a gantry crane which covers the whole of the floor area in the bay. There is, in addition, a straight line crane for smaller sizes of barrels.

Fig. 7.—General view of the end of the shop in which the plating plant is installed.
The main extraction fans can be seen on the left hand side of the shop. The pit on the right hand side is for a separate line of tanks for processing smaller barrels.

Conversion of a Frit Kiln to GAS FIRING

THE manufacture of frit, for the production of vitreous enamels or ceramic glazes, is carried out at temperatures varying, according to the composition of the mix, between 1,240 and 1,320° C. Recently a coal-fired static frit melting furnace at the works of Hargreaves Mill Ltd., Hanley, Stoke-on-Trent, was converted to town gas firing by the North Staffordshire Division of the West Midlands Gas Board.

The kiln converted is of the static type, with a hearth sloping inwards from both ends, and having internal dimensions of 11 ft. 9 in. × 3 ft. wide × 2 ft. 6 in. to the crown of the arch at the point of "run off".

The furnace is lined with 9 in. of firebrick (Douglas F. or similar), backed with 2 in. of china clay and 9 in. of good building brick.

Modifications Carried Out

The coal fire mouth at the front of the furnace was removed completely, thus shortening the length by about 5 ft. A No. 6 Schieldrop self-proportioning air-gas burner was then mounted centrally on the bridge wall, certain alterations being made to the burner to enable it to pass 2,500 cu. ft. gas per hour. Air is supplied from a fan at a pressure of 10 in. w.g. and is pre-heated to a temperature of 160° F.

Performance

Gas Firing

Tests were carried out over a period of 28 days. In continuous production the furnace dealt with 195 charges producing 73 tons 18 cwt. of frit. The gas used over this period, including drying out and initial heating up, was 1,532,500 cu. ft. (7,202·275 therms). With gas at 10·9d. per therm, the total cost was £327 2s. 6d. and the cost per ton of frit produced was 88·5 shillings.

Coal Firing

During a test made over a period of 31 days continuous production, coal used was 61 tons 7 cwt. of No. 1 washed nuts, having a calorific value of 13,490 B.t.u. per lb. The price of this coal was 91s. 10d. per ton delivered. The output of frit produced was 66·5 tons and the average cost per ton of frit produced was 84·9 shillings.

Observations

Whilst on basis fuel cost gas is slightly more expensive than coal, it will be appreciated that there are attendant advantages which more than offset this increased cost and in fact, favour the use of gas. Probably the most important is that frit of an improved and more constant quality is obtained during the fritting period, the product being completely free from contamination by ash or sulphur.

The wear and tear on frit furnaces is heavy but is less with gas firing than with coal firing. In actual fact repairs were necessary to the bottom and side walls every four weeks with coal firing, whereas with gas firing, 13 weeks' production could be obtained before similar repairs became necessary. The same applies to repairs to the main arch, comparative periods being 12 weeks with coal and 36–40 weeks with gas.

An increased output of approximately 10 per cent. is obtained with town gas over a given working period, due to time saved by the elimination of loss of temperature arising from clinkering necessary with this form of coal firing.

We are indebted to the West Midlands Gas Board for the information on which this description is based.

NEW I.C.I. FILM ON METAL PRETREATMENT

AT the end of last month the first public viewing of a new film on the subject of "Metal Pretreatment" was shown to an invited audience in Birmingham. The film was produced by Imperial Chemical Industries Ltd., and is entitled "I.C.I. Metal Pretreatments in Industry". It runs for seventeen minutes and is designed to focus attention on the importance of adequate pre-treatment of metal surfaces prior to painting.

The film begins by showing familiar examples of corrosion and paint failure and indicates how their main causes—industrial atmospheres and humid conditions—can be countered by the adoption of the Granodine phosphating process.

Application of "Granodine" in various industries is illustrated by visits to pretreatment plants to see the wide range of products, including cars, washing machines, carpet sweepers, and record players, which are pretreated prior to painting.

The importance of "Deoxidine" for rust removal is also explained and is effectively illustrated by showing badly-corroded agricultural equipment before and after treatment in "Deoxidine".

The protection of aluminium is also covered. The need for a practical, rapid and economical method of protecting aluminium and its alloys has been met by the introduction of "Alocrom", and the camera visits an aircraft factory and a large motorcar factory to see the industrial application of this process as a pretreatment prior to painting. Its use as a protective and decorative treatment for aluminium without painting, particularly on aircraft hangars and portable buildings, is also mentioned.

THE INSTITUTE OF METAL FINISHING • 1957 ANNUAL CONFERENCE IN BRIGHTON

Report of Technical Sessions

(*Continued from page* 176, *April*, 1957)

The Cleaning of Intricate Parts

By H. Silman, B.Sc., F.R.I.C., F.I.M., M.I.Chem.E and J. E. Entwistle*

THIS paper is devoted in the main, to a consideration of ultrasonic cleaning. Although the cost of the plant for this process is somewhat heavy, the speed and certainty of the process makes it well worthwhile, particularly for articles where failure can be serious or whose market value is high. Essentially an ultrasonic plant consists of a tunable ultrasonic oscillator, a power amplifier, a transducer which converts the electrical energy into acoustic or mechanical energy and a container made of glass or stainless steel in which the articles are immersed in the liquid cleaning medium. The solvents used are generally chlorinated hydrocarbons which are particularly suitable for ultrasonic cleaning because of their di-electric properties. For certain applications, aqueous solutions are preferred, particularly in conjunction with low-frequency oscillators. In such plants the transducer element is either enclosed in a stainless steel sheath or mechanically attached to the tank wall. Magnetostrictive transducers are available which can be immersed in a tank of fresh water attached to the cleaning bath so that the waves are transmitted to the latter directly.

In addition to magnetostrictive materials such as nickel or cobalt alloys, piezoelectric crystals such as quartz or plates of titanates of barium are used for transducers. Magnetostriction is mainly used for frequencies below 3·8 Kc. and piezoelectric transducer for higher frequencies. The shock waves in the solvent produced by the oscillations cause vibration and cavitation in the liquid which exerts the cleaning action.

The magnetostriction system is most suitable for the application of very high power for long periods owing to the considerable fatigue strength of the nickel alloys used.

For the cleaning of small components, frequencies of the order of 400 Kc. are preferred, since at lower frequencies excessive cavitation occurs resulting in pockets of vapour and the impingement of the cleaning liquid on the surface of the articles. This violent action, while useful for removing heavy deposits, is not considered particularly good for dealing with the minute particles of lapping compound and the extremely thin surface films which are the most difficult to remove on such articles. On the other hand, at very high frequencies, energy losses during transfer of the transducer oscillations to the cleaning medium tend to be high. Increased density in the cleaning medium also favours cavitation, and hence the cleaning action, which accounts for the usefulness of chlorinated hydrocarbons in this field. High volatility has the converse effect. Likewise high temperatures result in a marked reduction in the improvement resulting from the use of ultrasonics, necessitating cooling of the plant, to effect a compromise between ultrasonic and chemical cleaning action.

The engineering industries provide a prolific field of application for ultrasonic cleaning. Watch parts for example, have provided an important field of application for the process because of the high standard of cleanliness required, the large quantity of components involved and their intrinsic value. A typical cleaning plant is of the manual type giving a high degree of flexibility in operation by the use of five separate compartments. The articles are placed in small nickel baskets, which can be vibrated mechanically at each stage. The first tank contains solvent for pre-cleaning, the second contains the ultrasonic head and can be partially evacuated, while the third and fourth compartments are for rinsing. In the fifth compartment, drying is carried out by means of dust-free air, the components being heated by an infra-red unit. The amplitude of the ultrasonic energy can be regulated and filtering and pumping equipment for the solvent as well as cooling and exhaust equipment are provided.

For fully automatic operation a rotary machine has been developed. As watch parts that have been cleaned ultrasonically are almost impossible to oil, it is often necessary to apply to the parts a thin film of stearic acid, by exposing the metal to the acid vapour.

*Director, Electrochemical Engineering Co. Ltd.

Discussion

MR. G. SCHMERLING (Silvercrown Ltd., London) said that the start of all metal finishing was the preliminary cleaning, and he felt sure that possibly 99 out of 100 failures and rejects were caused by bad cleaning rather than by the plating solution.

The authors had referred to the various methods of cleaning, and had dealt with emulsion cleaning and especially the di-phase cleaning used in machines. He believed that there was one plant in this country which was operating with a single-phase stable emulsion cleaner right in the cycle; that was an interesting possibility not referred to in the paper, and it would be interesting to know the opinions of the authors and the audience about it. Most members were concerned with cleaning as a preparation for plating, and if it was possible to have the complete cleaning process right in the cycle in an automatic plant it would be an obvious advantage.

The paper dealt mainly with cleaning by ultrasonic waves being beamed through a cleaning fluid and cavitation of the fluid during the cleaning. He understood that there was also a possibility of applying the ultrasonic waves direct to the work and not necessarily having a cleaning fluid at all. This had been done on the Continent for soldering. and he asked whether it was essential to apply the ultrasonic effects through a cleaning fluid. He also wanted to know the voltage used in ultrasonic systems, both piezoelectric and magnetic.

He presumed that he was right in assuming that ultrasonic cleaning was not meant as a substitute for conventional cleaning methods, but was solely to deal with certain cases of intricate parts. He supposed that for ordinary purposes, alkali cleaning would still be used.

MR. J. CHADWICK (Joseph Lucas Ltd., Birmingham) asked for information on the current consumption of the ultrasonic cleaning plant shown in the paper and what surface area of components could be efficiently cleaned by it in a given time, say one hour?

Furthermore, had ultrasonic cleaning on automatic plating plant been considered? Was it useful in aqueous solutions, or was the cost prohibitive?

MR. B. E. BUNCE (Gillette Industries Ltd., Isleworth) said that his company had had some experience in the use of automatic degreasing plants, particularly for small parts, and were satisfied with their advantages in saving labour, etc. He should like, however, to comment on a corrosion problem which had arisen, particularly when degreasing parts where water-soluble oils had been added in cold-forming operations.

It had been found that complete removal of the galvanized coating inside a plant could occur when using trichlorethylene at the liquid/vapour interface, resulting in severe rusting. This problem had been further complicated by the apparent acceleration in the rate at which the solvent decomposed in the presence of water and/or rust. This type of acceleration and breakdown had been confirmed in the laboratory. Complete replacement of the galvanized coating has already been carried out in one of the company's plants, and the use of stainless steel as a liner was being considered. Could the authors comment on this type of problem?

Turning to the use of ultrasonic degreasing, he admitted at one time, to have been sceptical of its value except for very special problems, but, having had the opportunity to operate a 400-kc/s plant, he could fully endorse all the claims which had been made for this type of cleaning, particularly for problems where blind holes were concerned, very small orifices, and articles where polishing or finishing compounds were forced into cavities.

MR. G. H. JENNER (Schori Division, F. W. Berk and Co. Ltd., London) said that he would like to make a slight criticism of the title of the paper. The title was "The Cleaning of Intricate Parts", and mention was made of emulsion cleaners and alkali cleaning. What was cleaning? Degreasing was one part of cleaning, and the removal of oxide and various soils, etc. was another. But alkali cleaners and emulsion cleaners did not normally remove oxide films, and a straight-forward dip into trichlorethylene also only removed the grease. He would have liked to have seen some definition of what was being taken off by the various methods of cleaning, because in his own experience, a component might look quite clean, yet it was not possible to do anything with the surface because it was too dirty.

MR. R. J. BROWN (The Austin Motor Co. Ltd., Longbridge, Birmingham) said that Mr. Silman knew to what extreme lengths the motor industry went to ensure cleanliness of the parts built into motor car engines. Could he give more information about this subject, and how would he suggest improving the cleanliness of parts?

He had not seen any of the installations of the type for which Mr. Silman was responsible, but, having read some of the published matter, they did not seem to go much further than the methods at present in use; the plants used the same sort of cleaning agents and cleaning mechanisms.

Completely to clean all the various orifices and oilways, etc., in a motor car, was an extremely difficult problem. Possibly the only way to ensure complete cleanliness was to put a high pressure flushing system through all the various oilways.

He was interested in the observation in the paper that following an emulsion cleaner it might be necessary to wash off in water. He thought that

one advantage of an emulsion cleaner for general cleaning purposes was that there was no necessity to wash off in water, apart from the electrodeposition industry, and that it was in fact an advantage not to do so, because a mildly protective film of oil was left.

Mr. S. R. Goodwin said that ultrasonic cleaning had been used in the textile industry for a number of years, and its recent application to metal finishing was of great interest. But what was the possible effect of the ultrasonic waves on the fatigue of certain metals and the newer alloys, and possibly on such things as spring tension?

Mr. W. Marchand (Standard Telephones and Cables Ltd., London) asked whether ultrasonic cleaning had any effect on magnetic swarf.

Author's Reply

Mr. H. Silman said that Mr. Schmerling had referred to stable emulsion cleaning. The existence and the uses of stable emulsions was known, but the view was taken that the stable emulsions were less satisfactory than the unstable emulsions, because in the latter case there was the advantage of the two phases getting into intimate contact with the surfaces being cleaned. With stable emulsions the oil phase was too highly dispersed to have anything like as solvent an action on the contaminants on the surface as that which could be achieved if the emulsion was unstable. There was ample evidence to prove this point.

His reference to the use of ultrasonic waves without a liquid medium was, he thought, based on a misunderstanding, because it was essential for the dirt which was removed to be transferred to something. Where ultrasonic cleaning was used in a soldering operation a liquid medium was provided in the form of flux and the oxide which was removed, for example, in the case of the soldering of aluminium was transferred to the liquid phase. A liquid phase was essential.

On the question of voltage, the machines operated on mains voltage so far as their connexions were concerned, but internally higher voltages were used, and in the paper reference was made to this. The high voltages were necessary because of the high impedance of the elements built into the tank.

Mr. Chadwick asked what was the throughput of the machine shown in the paper. The tanks were able to hold perhaps 2 lb. of the articles being cleaned, and they had to stay in the tank only for 30 sec. The limiting factor on the output of a plant of the type under discussion was not the time for which the articles had to stay in the tank; it was determined entirely by the rate at which it was possible to clean the solvents by the high-speed filtration system employed. If very highly contaminated material was put into these tanks, the solvent would not be cleaned for the next cycle as quickly as would be the case if the articles were less highly contaminated. It would be necessary to wait for the filtration to do its job before putting the next batch through. The physical capacity of the plant was largely determined by the speed of the filtration system and the degree of contamination.

Whether or not it was possible at the present stage to install ultrasonic cleaning in the line in a plating plant was debatable. He would not like to say that the system was suitable for that purpose, because of the complications which had been described.

Effect on Galvanized Coatings

In reply to Mr. Bunce, Mr. Silman said that it was true that galvanized coatings could cause trouble in ultrasonic cleaning plants, and for that reason stainless steel or glass containers were preferable for the actual operation. The stability of trichlorethylene under ultrasonic conditions was still undetermined, but it was known that even with conventional methods of degreasing it was possible to run into trouble with solvent stability, for reasons which were not always known or clearly understood.

Mr. B. E. Bunce said that he thought that Mr. Silman had misunderstood him; he referred to the breakdown of the coating in a standard plant.

Mr. Silman said that one of the principal reasons for that had been the introduction of light-alloy swarf, which was known to result in decomposition and breakdown of the stabilizer using chlorinated hydrocarbons, and stainless steel had been used more satisfactorily than galvanized material. Nevertheless, large numbers of galvanized steel solvent degreasing plants were in use, and if the trouble were widespread they would have been thrown out long ago.

Mr. Jenner criticized the title of the paper. In self-defence he would say that in his view the title was usually chosen to attract an audience rather than to describe the contents.

With regard to Mr. Brown's comments on the cleaning of engine parts, while Mr. Silman was not prone to prophesy, he ventured to guess that in a few years time the present standard and methods of cleaning of engine cylinder blocks would be considered completely obsolete, and it would be difficult to understand how any motor manufacturer dared to put out an engine in its present state. It was true that every precaution was taken to get the engines as clean as possible with present methods and equipment, but with increasing knowledge of cleaning methods and processes, present methods might be considered obsolete. That was no criticism of what the motor industry

were doing now; they were, however, limited by available processes and equipment. These processes would undergo very serious modification, as had been seen in the case of cleaning operations for other equipment, for aircraft engineering and particularly for hydraulic systems, where methods formerly considered quite satisfactory were now considered very unsatisfactory indeed.

He thought that it was desirable when using emulsion cleaners to wash off the residue as far as possible, because the emulsions contained dispersing and emulsifying agents, and, though they were carefully selected to have as little corrosive effect as possible, the less left on an article after cleaning in the way of materials of that kind the better.

Mr. Goodwin had referred to the effect of ultrasonic waves on fatigue. It was well-known that the passing of vibrations through metals could cause fatigue, and if a magneto-strictive ultrasonic generator was oscillated too rapidly it was possible to shatter the nickel core of the transducer itself; in actual practice the limits of energy input for cleaning purposes were kept fairly low, and so far as was known, this hazard was not a real one. It could be assumed that if an article did not break during the cleaning operation its fatigue limit was not likely to have been exceeded and it would not cause trouble subsequently.

Mr. Marchand had referred to the removal of magnetic swarf. Ultrasonic cleaning did not demagnetize the swarf during the course of the cleaning operation, but it would remove it. However, if it moved into the vicinity of the metal once more when the ultrasonic vibrations were taken away it would be redeposited. With the agitation to which the solution was subjected, however, and the circulation of the fluid, there was every chance that a very large proportion would be removed after being detached by the ultrasonic vibrations and would be carried away and retained on the filter.

Possibilities of Automatic Control in the Electroplating Industry

By J. W. Cuthbertson, D.Sc., F.I.M., A.M.I.E.E., and*

J. E. Parton,† B.Sc., Ph.D., M.I.E.E., M.I.E.S., A.M.I.Mech.E.

"AUTOMATION" is usually taken to mean the logical overall control of a number of items of production, each one of which may be under separate automatic control. It is this wider integration of control that is now being attempted.

Although there is an enormous variety of control systems it is possible to discern four major categories *viz.*, sequence controls, regulators, servo-mechanisms and process controls. Another mode of classification is into open-loop and closed-loop controls. Sequence controls ensure that a pre-selected sequence of operations is carried out, *e.g.*, traffic lights, transfer machines, etc., and these controls are of the open-loop type, in which the input instructions are passed down from the controller through a more or less long chain of control units until they reach the load it is desired to control. The controller has no knowledge whether or not the actual response of the output or load is as required. This should be compared with the closed-loop system where information about the behaviour of the load is fed-back to the controller, thus enabling the controller to modify the control signals in accordance with the output instructions and the output response feed-back in opposition.

Regulators are devices which hold some physical quantity such as temperature, liquid level or voltage at a predetermined value and the control action may be continuous or discontinuous. Servo-mechanisms were developed mainly for the armed services and process controls have very much in common, but they were developed independently, and are in use, for example, in the oil and chemical industries.

Process control with closed-loop continuous action appears to be the most suitable to electroplating processes, and the response of a simple system of this type to changes will depend on the characteristics of the regulating unit, of the plant itself, of the detecting and measuring unit, but most of all on those of the controlling unit where adjustments can usually be made. However, the problem of choosing the most suitable control action is very complicated; it not only requires consideration of the desirable control response characteristics, but economic and safety factors are also involved.

Under ideal circumstances, for a process having physical and chemical changes, it will be possible in principle to set up a series of simultaneous equations representing, heat transfer, chemical kinetics, etc., which can be used as a basis for calculating the effects of changes in the various process conditions. However, in some existing plants under manual control it may be necessary to carry out planned experiments on the plant itself.

The conversion of a plating process to automatic control is complicated by variables such as temperature, current density, solution composition, electrode dimensions and spacing and degree of agitation of the electrolyte. Successful operation is dependent on the control of all these variables within certain limits.

Temperature is normally controlled by thermostats, but as regards the second variable the readily

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† *Professor of Electrical Engineering, University of Nottingham*

controllable parameter is current, not current density, as no accurate method of measuring cathode current density has yet been devised. The complication and cost that would be involved in applying automatic methods to control completely the chemical composition of a plating electrolyte do not appear to justify their adoption on a wide basis. However, there is much to be said for limited control applied to major variables of metal concentration and *p*H, etc.

The control of inter-electrode spacing and cathode-to-anode area is likely to be simplified if the interelectrode spacing can be made constant and if the cathode area is equal to the anode area. The problem is to obtain the closest approximation to uniform current flow. The required control of agitation devices should present no difficulty. Having obtained individual closed-loop controls on the variables it is a natural development to interlink them into an integrated multi-loop system to take account of the various modes of interaction of the variables. The use of a central computer controlling the whole deposition process should enable it to be self optimising for different electrode assemblies.

Discussion

Mr. A. Smart (Managing Director, Electro-Chemical Eng. Co. Ltd., Woking) said that the problems and difficulties encountered in designing an automatic transfer machine for cylinder blocks were very similar to those encountered in designing automatic plating plant He had felt, therefore, that there were certain underlying principles in the design of these automatic machines and mechanisms and that it would be a very good thing if, instead of trying to solve individual problems as they arose, a better understanding was obtained of the fundamentals underlying these problems. The paper gave a good basis for the theoretical consideration of these matters.

Most of the control systems discussed, he said, were divisible into open and closed loops, but he suggested that there was an intermediate type which was in fact a controlled open loop. When he was first concerned with automatic plating plant, many years ago, he tried to make the plant work with a sequence controller. The only trouble was that after the first set of operations it was 0·1 in. out, and after the second set it was 0·2 in. out, and it got further and further out of step. He believed that there was an intermediate stage, between the open loop and the closed loop, in which a metering or controlling device indicated when the operation being controlled moved outside the tolerable limits.

If something was required to go from *A* to *B*, an open loop would set the thing (whatever it was) going from *A* to *B*, but if it wandered off, the open loop control would not take any notice. A closed loop would bring it back and make it go to *B*. In many electroplating problems that was very difficult to do, and it was unlikely for many years to be economically justified; but what was useful was to have a control system which started the thing going from *A* to *B* and then, if it went outside the permissible limits, said Stop! so that there is a chance to put it back on the rails again. If that happened only very occasionally, it was a preferable alternative to a much more complicated system.

Number of Variables

In the paper the authors listed a number of the variables in electroplating—temperature, current density, solution composition, etc. To imagine an electronic computer set to cover all the variables in solution composition and everything else and to ascertain them was, he thought, outside the realm of practical politics; but, to take two of these variables, it was known that very often maximum current was related to temperature, so that if the temperature were to fall a device could be made which would say "reduce the current". At the same time, it would be necessary to maintain the plating specification, so that if the current was reduced the time of plating would have to be increased. The complications involved in going through all these variables would rule that out of consideration; but what could be done was to have an automatic temperature control of the open-loop type and turn it into what he had called a controlled open loop. In other words, the temperature controller should be allowed to work within the range prescribed for it, and, if it went outside that range, there should be another device which said Stop! Then, by manual intervention, it would be possible to do something about it.

At the present it might be appropriate to consider, more than is done, the introduction of more automatic aspects in fully mechanized conveyor machines. For example, many brighteners were used up on an ampere-hour basis, and advantages would accrue from ampere-hour-meter control of brightener which would only require periodical checking.

Optimum Current

In plating plant it was rarely possible to deal with current density. There was, however, an optimum current per rack. With one rack, one tank and a skilled operator, it was not easy to adjust the voltage on the tank to give the best current for plating the rack. But if a rack consisted of nothing, say, but 1 sq. ft. of sheet, it was possible to devise an automatic device which would give the right rising voltage characteristic so that each rack was given its correct current. With a voltage regulation curve on the output of the rectifier, as each succeeding rack was placed in the vat the current would

increase in uniform steps. This arrangement would work, however, only so long as each rack consisted of 1 sq. ft. of identical sheet. The difficulty could be overcome if standard racking systems were used, as they were to an increasing extent today, by putting into the stem of each rack a resistance which was then adjusted so that each rack would take its correct current when it worked off this voltage characteristic. By that means it would be possible to make two apparently totally different loads—a number of headlamp rims, for example, and perhaps a radiator shell—appear from the point of view of the control system to be identical.

There was another considerable advantage in putting the resistance in, because the current on any rack could be written as $I=\frac{V-E,}{R}$ the applied voltage (V) minus the back e.m.f. (E) divided by the total resistance of the circuit (R). Very often in the plating circuit the total resistance was quite small, and a plating rack in its passage round an automatic plant would undergo large variations as it moved from one position to another. If, however, a resistance R^1 was inserted in the rack stem then $I=\frac{V-E,}{R+R_1}$ and the mere introduction of the resistance, which would act as a ballast resistance, would reduce the difference in the current which each rack took.

If the resistor was made with a narrow "neck" in the centre of its length, the high thermal coefficient of the resistance element would produce a considerable self-compensation effect.

By adopting methods of this type he believed that it would be possible to go a considerable way further than had been done so far in introducing some form of automatic current control; each rack would be given its optimum current, which really meant giving each component its optimum current density, though it might not be the same one.

Mr. E. A. Ollard (Atlas Plating Works Ltd.) said that he believed that automation was the ability to make a plant run without human intervention, at any rate in its ordinary everyday life, and in order to achieve this it was more or less obvious that it would have to do at least everything that the human operator did at the moment, and that introduced, as Mr. Smart had said, the coupling up of the various controls, so that when one factor altered another was altered to suit it.

It was possible to obtain digital controllers which would take decisions on such matters. It had been emphasized that apparatus of this type did not "think" in the ordinary sense of the word, but those who had spent a good deal of their lives in plating shops would agree that there was no experimental evidence that a plater did think!

In a plating plant it was not required to alter one factor to compensate for another, but to keep the one factor just where it was required. He would not like to have a plant in which, when the temperature dropped, the control dropped the current density and increased the time. He would prefer to have a control which put the temperature up again. It seemed to him that that type of overall control was not wanted so much in that respect as perhaps in others.

The first thing that automated plants of that type ought to be able to do was to look at the product which they made, and, if more than a certain percentage went outside a certain tolerance, either stop the plant or ring up the managing director! It was obvious that one of the most important things in an automated plating plant, therefore, was to have some automatic inspection of the plated components, particularly as a good method of manually inspecting had not been discovered.

There was one important aspect of the problem which had not been dealt with in the paper. There was no great difficulty, in theory at any rate, in controlling automatically all the variables at present controlled by human agency. With many solutions it was possible to design and make an automatic set-up which would test and correct those solutions at least as well as it was being done at the moment, if not as well as it should ideally be done. No complete answer had yet been found to the question of impurities in the solution, which was one of the industry's main troubles, so that it would be no worse off with an automatic plant than it was with the manually-operated one.

Problems of Handling

It was possible to make a transfer mechanism to put the work on a standard automatic conveyor into the automatic plant, and to take it off at the other end, but so far there was no machine which would either wire up or pick up the work and place it on the conveyor or take it off, inspect it and pack it. Those were two troubles which would have to be overcome in a fully automated plating plant in which no direct labour would be employed at all except perhaps for maintenance. If the plant were to be really automatic, there would have to be machines to take the work in bulk from boxes or hoppers, put it on a plating jig, hang it on a conveyor, pass it through a series of operations each of which would be controlled, and finally take it off and inspect it. It would be at that point that the overall controller would be needed, because if the inspecting device turned down more than a certain percentage, there would have to be some sort of computer which would stop the plant.

Mr. J. Chadwick (Joseph Lucas Ltd., Birmingham) agreed with the authors that the controls suggested were possible, at least theoretically, but the question which required consideration was to

what extent it would be an economic proposition. Automatic current control, together with automatic loading and unloading, would eliminate one operator, while current control without automatic loading and unloading would make it possible to employ an operator who could not read.

Chemical Control

With regard to chemical control, it should be a case of "All or nothing at all". Unless the control was complete, automatic *p*H control could not be justified. Only in the case of nickel solutions was *p*H measurement considered to be essential, and modern nickel solutions, whatever their faults might be, were well buffered, requiring, under stable operating conditions, only a daily *p*H check and usually a small addition of acid, taking a total time of about ten minutes, whereas automatic *p*H control would cost several hundred pounds.

Mr. Chadwick doubted whether automatic chemical control would save the analyst's time, estimated at ten hours a week in the case of an automatic nickel-chromium plant, as much of this time might be spent in replenishing the automatic analysis apparatus.

Nor would there be an obvious saving in maintenance time as the various chemical additions would have to be added through the control apparatus, and very probably in solution form instead of in concentrated form through the mixing tank. Insolubility of the chemical in water would present serious difficulties whereas the present practice of putting it in solid or concentrated form through the mixing tank did not take very long.

Thus to raise the *p*H, if that were necessary, in a bright nickel solution one could not very well add nickel carbonate. Furthermore, if the control were to be complete, then the cleaners and the acid dips should also be included.

Mr. A. W. Wallbank (Ionic Plating Co. Ltd., Birmingham) said that any analogy with the chemical manufacturing industry could only be superficial; admittedly both were concerned with temperatures and concentrations and so on, but otherwise they were quite dissimilar. The greatest difficulty of all in plating was the great variety of the work which was plated. In the simplest section of his own works about 40 tons of work was plated a day, but that 40 tons was spread over at least 200 separate batches, and those batches varied almost incredibly among themselves in weight, in surface area per lb., in batch size and in every other characteristic.

Actually, in view of the difficulties, the industry had gone a long way already. The process sequence control was certainly very good today. The modern automatic plant with its transfer mechanisms on the one hand, and the modern plating plant on the other, were outstanding developments in automatic equipment, even if not reaching full automation. The next stage was regulation, cutting out the personal element as much as possible in the control of plating conditions. Most of the rejects were not due to faulty cleaning, but to little slip-ups on the part of the people in control of the plant.

Every effort should be made to provide good current density control, reliable thermostats, something which would spot pitting before it started, and so on.

Economics of Control

The economic side presented very great difficulties which could be represented in the following manner. A certain volume of work required 20 operators, £2,000 worth of equipment, and half maintenance man. With 10 operators and 1 maintenance man it would need £5,000 worth of equipment for equivalent output. To cut the number down to 5 would cost £15,000, to cut it down to 2 about £50,000, and to bring it down to zero about £250,000. The number of maintenance men required in these various steps would go up 1 : 1½ : 2 : 4.

Operators	*Maintenance Men*	*Equipment Cost* £
20	½	2,000
10	1	5,000
5	1½	15,000
2	2	50,000
0	4	250,000

An accountant would look at that and ask how many man-hours would be saved and how much would be saved in wages to put against the money invested, over a period covering the complete depreciation of the plant. Normally, therefore, conversion would only be carried as far as that stage of making the process automatic which was most economic.

Mr. U. F. Marx said that a variable in the plating field not mentioned in the paper was the swill water which was relatively very easy to control, as had been done to some extent. Various means of controlling it had been used, and the usual control parameter employed was conductivity.

Apart from the saving in water—which would be tremendous, and would mean something to everybody in the Birmingham area—it should help to improve quality, because with process control by means of conductivity it was easy to install an alarm so that if the conductivity went over a certain figure bells would ring, lights go on and so on.

Dr. D. N. Layton (Ionic Plating Co. Ltd., Birmingham) said that, contrary to the authors' statement that there was no method of measuring current density accurately, a variety of devices had been put on the market at various times which were alleged to measure current density but in fact did not do so, but one had been developed which was

not on the market but which was effective. It had been described some twelve months previously in the technical literature* and had been developed by the G.K.N. research laboratory.

Briefly, it comprised a little search coil which was put close to the cathode surface, though not necessarily in contact with it, and it actually measured the true current density at that point.

Mr. C. M. PROSSER (Ionic Plating Co. Ltd., Birmingham) said that the overall control of a number of automatic processes was much the same in any industry. In the electroplating industry the problems were mainly concerned with the regulation of various processes. The question of current density could be dealt with in many instances merely by control of the jig, the same current being used each time and simply switched on and off. The biggest problem seemed to lie in solution control, and the authors had separated out *p*H and metal composition as possibly subject to this more than the other factors. In many cases, however, metal composition was controlled rather in its ratio to other constituents in the bath or vat, so that it could not be separated in the way suggested; the measurement of *p*H could more easily be done by a chemist, since a chemist would be needed in any case to control the composition of the vat.

Authors' Replies

Professor J. W. CUTHBERTSON said that no one had referred, in talking about the alternatives to automation, to the important question of the time saving which automation made possible. There must be something attractive in having a plating solution which was constantly, the whole time, on or near to the correct composition, as an alternative to relying on an analyst who analysed at intervals, when the solution was to some extent out of control, and then adjusted it. With many of these variables an attraction of automation should be the possibility of being able to correct errors quickly.

Mr. Smart's comments on a possible method of adjusting jigs by putting in resistances were interesting as he still contended that ultimately the parameter which required controlling was current density, and that was a way which in practice had shown some advantages. At the same time, Dr. Layton had referred to the measurement of current density. While he was not familiar with the instrument to which he had referred, he had still to be convinced that it was possible to measure current density with accuracy on the actual surface of the work. A device placed in the bath might be approximately correct, but in his view it is not the same as actually knowing the current density calculated from the area and the actual current flowing.

He could not let Mr. Ollard get away with the statement that the authors had evaded the issue on mechanical handling. This had been done deliberately as previous papers had covered quite well the mechanical parts of plants, and to avoid repetition they had avoided the purely mechanical side of conveying work through the plant.

There were some examples of attempts to convert a plating process into a wholly automatic one, which had gone a long way, and the chances of developing a purely automatic plant, with everything subject to automation, increased greatly if the type of material being plated was simplified. Therefore, this type of development had probably gone further in electro-tinning and electro-galvanizing than it had in plating articles of other than a smooth, flat type.

Professor J. E. PARTON said that Mr. Smart had introduced what he called a controlled open loop which was really an elementary closed loop, but so elementary that it would be a long way back in the development. It would be the method which would be tried first, to stop the process when it went too far wrong and call in somebody to put it right. That would be done for a few months before building in some equipment to save calling someone in.

Mr. Wallbank had doubted whether the chemical industry had much in common with the electroplating industry. It was most important in an automatic control system to have a constant product. With a variety of articles to be plated the process could not be automatic. One envisaged a mass production process with automatic control with literally millions of the same article going through, and then it became economic.

Dr. Layton had talked about the measurement of current density, which was analogous with the old problem of stress. It was not possible to measure stress, but it was possible to measure force and area and divide one by the other. One could measure current and area and divide the one by the other to get the current density.

Many of the difficulties of computer control had been mentioned by various speakers. The whole essence of the control of processes was the rapidity of measurement of the quantity which was to be controlled. If it took a day to take a sample and get the answer in the chemical laboratory, automatic control was out of the picture. Some method of measurement had to be used which would give a rapid indication of the quantity which was to be controlled and rapid meant within the response time of the system itself. There might be a time-lag built into it, but all the quantities had to be measured within that period. If the time-lag was of the order of a second, the measurements should be in milliseconds.

*See *Metal Finishing Journal*, (7), 1, *July*, 1955, *p*. 318

FINISHING NEWS REVIEW

SUMMER SCHOOL IN VITREOUS ENAMELLING

I.V.E. to stage annual course next month at Droitwich Spa

THE seventh week-end residential Summer School in vitreous enamelling organized by the Institute of Vitreous Enamellers will be held this year at the Worcestershire Brine Baths Hotel, Droitwich Spa on June 14-16. This represents a departure from previous practice as all the earlier schools have been held at Ashorne Hill, but the general pattern and intensive nature of the school has been maintained.

The programme is as follows:—

Friday, June 14

12.30 p.m. Assemble in Birmingham for lunch. After lunch proceed to Works Visit at the Parkinson Stove Co. Ltd., Stechford, Birmingham.

5.15 p.m. Leave Birmingham for the Worcestershire Brine Baths Hotel.

After dinner at 8.00 p.m. there will be a discussion on enamelling works practice in the light of the works visit.

Saturday, June 15

8.00 a.m. Breakfast.

9.00 a.m. *Second Session:* Film and Technical Paper dealing with Electrostatic Spraying — S. Hallsworth (Henry W. Peabody (Industrial) Ltd.)

10.15 a.m. *Third Session:* "Enamel Processing with special reference to architectural enamelling" — J. Guy (National Enamels Ltd.).

11.15—11.30 a.m. Break.

11.30—12.30 p.m. *Fourth Session:* "Preparation of Steel for Vitreous Enamelling with special reference to continuous pickling" — J. A. Stack (Curran Engineering Ltd.).

1.00 p.m. Lunch.

2.00 p.m. *Fifth Session:* "Chipping Resistance of Enamels" —S. Ryder (Stoves Ltd.).

3.00—4.00 p.m. *Sixth Session:* "Works Management and Human Relations" — C. S. Beers (Leisure Kitchen Equipment Ltd.).

4.00—4.30 p.m. Break.

4.30 p.m. *Seventh Session:* "Design and Colour" — A. Ross (Wengers Ltd.).

7.00 p.m. Dinner.

After dinner those attending the school will be addressed by Mr. W. Thomas, Chairman of the Council of the I.V.E.

Sunday, June 16

8.00 a.m. Breakfast. School disperses.

Application forms and full details of the School are obtainable from the Secretary of the Institute of Vitreous Enamellers, Mr. J. D. Gardom, Ripley, near Derby.

OPEN DAYS AT SKETTY HALL

THE British Iron and Steel Research Association will hold two Open Days at the Sketty Hall, Swansea laboratories, on Wednesday and Friday, June 19 and 21, 1957, for representatives of B.I.S.R.A. member firms and users of steel sheet and strip.

Demonstrations will be given on the recently installed experimental line for the production of PVC-bonded steel strip, and on the differential roller tinning pilot plant now being built. Other projects, including the continuous lacquering of steel strip, the use of iron-zinc and iron-tin alloys, and research into methods of gaseous deposition of metallic coatings, will also be displayed and demonstrated.

NEW HEADQUARTERS FOR C.D.A. IN LONDON

THE Copper Development Association, which was founded in 1933, recently opened its new headquarters and showrooms at 55 South Audley Street, London, W.1. The main function of the Association is to provide technical information and advice on applications of copper and copper alloys and to provide a link between research and industry. The Association maintains close contact with technical bodies in Britain, France, Germany, Switzerland and America, as well as with the International Wrought Non-ferrous Metals Council, through the recently-formed Copper Development Directors' Committee. The Association has 28 different publications available, all issued free of charge, and a number of films relating to various aspects of the production and use of copper and its alloys.

NEW LABORATORY FOR RESEARCH INTO PRODUCT FINISHES

EXTENSIONS to the laboratories of Mody and Co. Ltd., the Warrington paint firm, are planned to provide additional facilities for research in the product finishing and maintenance painting fields.

A new single-storey building covering a ground area of approximately 2,000 sq. ft. is now being built. It will be equipped and ready for use by June of this year.

Until some 14 years ago, Modys specialized in paper varnishes, French polishes and spirit enamels, etc., and it was for the manufacture of this type of coating that the company was originally established. The widening of their interests resulted in the company being one of the earliest surface-coating manufacturers to develop paints based on "Epikote" resins and the new laboratory will be largely devoted to work with these materials, thus freeing the existing laboratories for more general investigations.

With a number of epoxide-based coatings already well established in the market, the directors of the company feel that a substantial increase in laboratory research is well justified.

Indian Factory for Pneumatic Tool Firm

New Company Formed

THE Consolidated Pneumatic Tool Co. Ltd. of London and Fraserburgh, announce the formation of a new company under the title of the Consolidated Pneumatic Tool Co. (India) Private Ltd. The new company has a directorate comprising Mr. G. J. Coffey, Mr. Norman Readman and Mr. V. Nimbkar (Managing). It will operate in Bombay where new factory premises will be constructed. The primary purpose behind this development is the manufacture of CP products within the country, and it is expected that operations will be in full swing by the end of this year.

NEW ENGINEERING USES FOR ELECTRODEPOSITED TIN AND TIN ALLOYS

Use of the Dalic process

COATINGS of tin, produced either by hot-dipping or electrodeposition, on steel sheet, in the form of tinplate are the most widely known and used coated material in the world, familiar to every housewife. Not so widely known, however, are the many applications of deposits of tin and its alloys in the engineering field.

The electrodeposition of metals and alloys for engineering purposes is a branch of electrochemistry, which has assumed very significant dimensions in recent years, and promises to be of even greater importance in the future.

One of the processes which is finding increasing use for the production of electrodeposits of engineering quality, particularly in North America and on the Continent, is the Dalic process.

As is generally known, this process which is operated and supplied in this country by Metachemical Processes Ltd., Crawley, makes possible the deposition of metallic and alloy coatings at very rapid rates on localized areas of components to very close tolerances.

One of the recent developments in the process has been the formulation of solutions suitable for the deposition of tin-zinc alloy by the portable anode technique. These solutions are novel in that no cyanides are employed, the alloy being deposited from organic amino complexes. The deposit has characteristics similar to the normal deposit obtained from the solution developed by the Tin Research Institute, although the grain size is slightly finer. The corrosion resistance of the coating is of the same high order as that given by coatings obtained from orthodox still vats. Tin-zinc alloy has several advantages over coatings of either metal alone in that it combines the anodic protective characteristics of zinc with the high intrinsic corrosion resistance of tin. The soldering difficulty frequently encountered on a zinc coating is avoided and the alloy plate provides an excellent surface for subsequent painting without pretreatment.

The tin-zinc alloy plating process has already found application in a wide variety of industries and may be expected to find much wider application still. The introduction of solutions suitable for deposition of the alloy by the Dalic process will undoubtedly widen still further the range of usefulness of both the alloy and the process.

Prevention of Fretting Corrosion

Another instance of very effective collaboration between tin and the Dalic process is in the provision of a soft buffer coat between two hard mating surfaces. For example, when the bearing of a ball or roller race is fitted with an interference fit on to a shaft, vibration between the two surfaces is very liable to set up fretting corrosion; the provision of a thin layer of a soft metal between the two faces is a highly effective method of preventing fretting. From the small number of metals which can be used for this purpose, tin appears to have the all-round advantage, and deposits of tin of the order of 0·0003 in. thick have proved very effective.

At a recent demonstration staged at the Crawley works of Metachemical Processes Ltd., a satisfactory deposit of tin to the exact thickness required was plated, using the Dalic technique, on to the inside of a bearing housing in a little over five minutes; subsequently the bearing was fitted to the housing and gave an excellent fit.

A further engineering application of the Dalic process is in the reclamation of worn diesel and aircraft engine main bearing shells. These normally consist of a steel shell carrying a layer of either silver or lead bronze with a thin surface layer of 7 per cent. tin-lead alloy. When this thin surface coating is worn, replacement of the bearing has frequently been necessary in the past. However, by using the Dalic process it is now possible to replate this coating with a dimensional accuracy within 0·1 mil. Not only has the use of this process considerably simplified the reclamation of the bearing, but the finer grained deposit produced by the Dalic process has been found to give considerably longer service life to the coating.

In these and similar applications, tin, one of the oldest metals known to man, is finding through the medium of one of the newest technical developments in the electroplating field, new ways of rendering valuable service to the engineering industries.

Non-Ferrous Research in 1956

Annual Report of BNFMRA describes progress in protective coating investigations

THE annual report of the British Non-Ferrous Metals Research Association outlines the comprehensive programme of research which was in train during 1956, much of which related to subjects of metal-finishing interest.

The steady expansion of the work of the Association has made it necessary to contemplate the erection of a new laboratory block adjacent to the present premises. Completion of this building and of modifications to existing buildings is hoped for by the end of 1958.

A considerable amount of the work of the Association is devoted to the investigation of corrosion phenomena and many valuable findings in the field of corrosion prevention are on record. In the investigations on surface protection increased financial support from the industry has made it possible to accelerate work on the corrosion of galvanized coatings in hot supply waters. Uncertainties as to the real cause of tank failure are being resolved by setting up pilot-scale tanks operating as would a domestic system. Numerous variables are introduced in the operating conditions and the construction of the tanks. In parallel with these tests, further studies are being made of coatings from baths containing alloying additions, some of which unfortunately introduce serious metallurgical difficulties in the galvanizing process. As and when the value of an alloy coating is established in a corrosion test and methods of applying it satisfactorily are developed, sheets coated with such alloys will be tested in the experimental tanks before making tests on an industrial scale.

Electroplating

The development of low-stress crack-free chromium deposits has been pursued and it has been demonstrated that the bath gives consistent results in continuous use and that the deposits give excellent protection against corrosion. Unfortunately they are not bright, and immediate effort is aimed to improve them in this respect. In the interests of members, patent protection has been sought in a number of countries.

A demonstration carried out last year of the method of operation of pilot lines of commercial bright nickel solutions resulted in the production of large numbers of bumper-bar over-riders plated in the conventional manner. Samples were set aside at different stages of the bath life and these have now been subjected to atmospheric exposure. It is already clear that as long as the baths appear to be in good working order as judged by currently available methods of test, there is little to choose between the resistance of a large number of components. Nevertheless there is room for over-all improvement. One factor studied in this connection is the possibility of differences in the corrosion-resistance of different types of nickel deposit.

Apart from the quality of the deposit, the avoidance of polishing is a vital factor in the industry. Work on levelling action has accordingly been resumed and as a first step a rapid electrochemical technique has been developed to indicate the probable success of particular agents. Levelling action by which a deposit tends to fill up the cracks and minimise polishing is not uncommon, but unfortunately additions which produce this result frequently have other (undesirable) effects and a great deal of work remains to be done to find materials with the best combination of properties.

The blistering of electrodeposits on zinc alloy die castings after exposure to the atmosphere is the subject of another investigation begun this year. From an examination of samples which had developed blisters during the plating process, it appears that those which are apparent immediately after plating are different in origin and character from the blisters which develop in service. Further samples initially free from blisters are being subjected to atmospheric exposure tests.

Surface Finishing

Other methods of surface finishing, notably the formation of anodic protective coatings on zinc and zinc alloy surfaces and the chemical and electrochemical polishing of aluminium, have also been studied. Under the first of these headings, abrasion- and corrosion-resistant films have been produced and in the interests of members patent protection has been sought in a number of countries. The search still continues for simpler methods with more attractive results.

Chemically or electrochemically polished and anodised aluminium and aluminium alloys are of course, widely used for decorative applications, and it appears that the use of these finishes on aluminium is rapidly expanding. For certain applications the optimum aesthetic appeal and resistance to corrosion and abrasion are required, and a survey of the position during the past year has shown that existing methods of testing and inspection are inadequate for such applications. Arrangements have been made to undertake some work in this field in the immediate future.

Institute of Metal Finishing Expands into South-West

Inaugural Meeting of New Branch in Bristol

THE Institute of Metal Finishing has announced the formation of a local branch to cater for the technical interests of metal finishers in the south-west area of the country. The branch will be known as the Bristol and South-West Branch and the inaugural meeting is to be held at the Grand Hotel, Bristol on June 4.

The meeting will be opened by the President of the Institute, Mr. R. A. F. Hammond, and a paper on "Recent Developments in the Finishing of Zinc Die-Castings", will be presented by Mr. L. A. J. Lodder. During the evening the Officers and Committee of the Branch will be elected.

The meeting will be preceded by luncheon at the Grand Hotel, Bristol, which will be followed by a visit to the works of the Bristol Aeroplane Co. Ltd., at Filton, by kind permission of the management.

The visit will provide an opportunity for members to see the Bristol Britannia, the world's premier civil aircraft, under construction. Visitors will also be able to see the electroplating departments where several specialized applications have been developed.

The evening meeting is open to all who are interested, but those wishing to attend the Works Visit and/or luncheon, should make prior application to Mr. J. Dixon, 20 Wellington Walk, Henleaze, Bristol. The number that can be accommodated on the works visit is strictly limited.

A NEW SYSTEM OF MANUFACTURE OF LAMINATED PLASTIC TANKS

THE advent of the reinforced or laminated plastics in recent years was enthusiastically welcomed by the electroplating industry, as well as other chemical industries, as offering an inert material of high strength which would be suitable for use in a wide range of applications. The type of this material, which has achieved the widest acceptance at the present time is glass fibre reinforced polyester resin, and tanks and exhaust systems in this material are already in use in the plating industry.

However, it now appears that for a number of chemical applications polyester laminates are subject to a measure of attack, due to capillary action between the glass fibres and the resin, leading to loss of strength.

For stands, exhaust hoods and swill tanks, polyester laminate is completely satisfactory and a range of equipment of this nature is manufactured by the firm of A. E. Griffiths (Smethwick) Ltd., in addition to the P.V.C. constructions for which they are already known.

The company has now introduced a new principle of manufacture for laminated plastic equipment based on their patented "twin-shell" system. This system, which is described in an 8-page brochure available from the company, consists of making a composite laminate, the inner skin in contact with the corrosive environment being made from furane resin which has excellent chemical resistance but low mechanical strength. The outer skin, being of polyester resin provides the required mechanical properties. For even more exacting conditions the outer skin can be made from an epoxy resin, which increases the chemical resistance of the outer shell, particularly to alkaline attack.

Yet another development is the use of terylene cloth in place of glass fibre as reinforcing material when hydrofluoric acid is present.

The company is equipped to give comprehensive advice on the selection of the most suitable resin or combination of resins for any particular application.

TRADE and TECHNICAL PUBLICATIONS

"Heavy-Current Low-Voltage Switchgear": This leaflet published by Electroloid Ltd., Chromaloid Works, Oaklands Road, London, N.W.2, describes a new class of switchgear that the company has developed over the last three or four years.

Hitherto the company have manufactured this equipment only against specific requirements and upon personal recommendations, but they now intend to put the equipment on general sale.

A particular advantage of this new switchgear over the standard knife switch is that it can be mounted in the busbar run, obviating the necessity for bringing long runs of copper down to ground level, merely to insert disconnecting switches for convenient hand operation.

"Lead": Red lead and white lead paints for the protection of steel highway structures such as bridges, are featured in the latest issue of "Lead". the quarterly publication of the Lead Industries Association, 60 East 42nd Street, New York 17. A bridge in New York is given as an example, together with the N.Y. State specification under which it was painted.

A new use for lead as an ingredient of low-temperature porcelain enamels for steel is also illustrated. The lead permits formulation of enamels that fire as low as 1,000 to 1,100° F, thus resulting in sheets of remarkable flatness and lack of distortion, at lower cost.

"Standard Colours for Kitchens": The views of eight experts on the question as to whether the colours for kitchen equipment should be standardized are stated in the April issue of "Finishing Facts", issued by I.C.I. Ltd., Paints Division, Slough. By a majority of five to three the experts representing manufacturers of domestic equipment and the Council of industrial design, cast their vote in favour of standardization, but the arguments on both sides make interesting reading.

"Multi-Colour Effects on Anodized Aluminium": The attractiveness of coloured anodic coatings on aluminium has considerable sales appeal, and this is now being enhanced by the technique of producing multi-colour effects. In their pattern card F.46 the firm of Bard and Wishart, 26 Brown Street, Manchester 2, the sole importers into the U.K. of dyestuffs manufactured by Durand and Huguenin, A.G., Basle, draw attention to those colours which experience has shown to be best suited to multi-colour work. The technique calls for the off-set printing of what is described as a "reserve" ink which is resistant to the consecutive stripping operations which the process involves. A remarkably fine example of multi-colour work on an aluminium sheet is included in the card, together with the dyeing schedule by which it was produced.

"Formulation for Airless Spray": The airless spray system for paint application, marketed in this country by T. C. Spray Finishing Systems, 5 St. James's Place, London, S.W.1, has been fully described in the technical literature in recent months. An article giving advice on the formulation of paint for application by airless spraying written by James A. Bede, originator of the process in the U.S.A., is available in reprint form from the company.

"Low Temperature Enamelling": Interest in the development and application of vitreous enamels suitable for use on aluminium and aluminium alloy sheets continues to develop at a rapid rate in the U.S.A. A description of a new mass production set-up for enamelling aluminium and aluminized steel at the works of the Porcelain Steel Corporation, Indiana, appears in the current issue of "The International Enamellist", published by Ferro Corporation, 4150 East 56th Street, Cleveland 5, Ohio. This installation is capable of handling sheets up to 40 ft. long and 54 in. wide.

"Etch Primer": Etching and priming in one operation by brush or spray application are the main features of "Preclad" metal primer described in a brochure published by Pinchin, Johnson and Co., 4 Carlton Gardens, London, S.W.1. This primer is designed to enable paint films to secure maximum adhesion to metals that usually need treatment such as etching, pickling, scuffing or abrading before painting. Only one operation is involved with the primer and no lapse of time occurs between the pretreatment and the application of the paint coating. The primer is intended for use on such materials as aluminium and its alloys, galvanized iron, zinc, zinc-alloy die-castings, chromium and cadmium plating, brass, copper and lead, but not magnesium and its alloys. In addition the primer can be used on iron and steel. "Preclad" is supplied in two parts, the "primer" and the "blender" which must be mixed together in the correct proportions before using. Before application, surfaces should be free from grease, oil, or other foreign matter.

Latest Developments in PLANT, PROCESSES AND EQUIPMENT

New Range of Pump Units

THE many technical advantages which can be derived from the use of circulating systems for the supply of paint to the application point have to a great extent not been available to any but the largest-scale users, because of the high initial and maintenance costs of such an installation. Furthermore there exists in the electroplating industry the need for a simple pump which is cheap to operate and completely inert to a wide range of chemical solutions.

Of considerable interest in both these applications, therefore, is the introduction of the Neumo pneumatic motor in conjunction with the Neumo range of pumps. These units are manufactured by the S.E.D. Engineering Co. Ltd. and marketed by Kingsbourne Products Ltd., South Coast Road, Peacehaven, Sussex.

The principal feature of the Neumo motor is that owing to its specially designed porting system it is completely non-stalling and can be operated at a wide range of speeds and powers from air supplies of widely differing pressures. The pump unit, shown broken down into its components in Fig. 1, is available in a range of materials, both ferrous and non-ferrous, and also in solid P.T.F.E., one of the most inert materials yet developed.

Recently, a trial plant was installed at the premises of a well-known manufacturer of domestic appliances with remarkable success. The company were able to install this system themselves, using their own technicians and maintenance staff. One of the major problems involving an inexpensive plant has been that of providing a means of propelling the paint through the system at reasonable cost and this was solved by the use in this case of one Neumo Mk. IV pump unit. The plant comprised the pump, 100 ft. of pipeline, a pressure-relief valve, several liquid cocks and two hot spray units and guns, which were already in use. At a total cost of about £50 a complete circulating system was installed, and by using existing labour, the cost was kept to an absolute minimum.

The layout is simple. The Neumo pump is fitted in a position where the inlet hose may be readily dropped into the paint drum. From the delivery side of the pump a line is laid to the spray booths and lead-offs are fitted, either to the hot spray equipments or direct to the gun positions, the line then returning to the paint drum. The pressure relief valve is incorporated to ensure that if one gun is not spraying, the pressure to the second is maintained at the correct figure. At least twice the amount of paint to be used at any one time must be circulated. Air consumption of the Neumo pump is only 3½ cu. ft. per min., and thus the cost of this is low. Complete cleansing of the system for colour change, etc., is effected by circulating solvent for an effective period followed by a flush through with clean solvent.

While one pump in this instance was just sufficient to pass the required amount of paint, it is strongly recommended that two pumps in tandem should be fitted, with provision for isolation of each, thus enabling any servicing to be carried out with the plant in operation. This also has the effect of reducing wear and consequently maintenance on the system. The main advantage of this equipment

Fig. 1.—Constituent components of air-operated pump unit for paint, solvent and chemical circulation.

is the considerable saving effected by purchasing paint in 40-gal. drums instead of the usual 5-gal. drums, so reducing the losses involved in dispensing from 5-gal. drums to pressure pots. Labour costs are also reduced and a saving is effected by rendering pressure pots unnecessary. There is also the advantage of having a central control over viscosities and fluid pressures at the gun.

The company concerned with this trial installation have announced their satisfaction and are now putting in similar but more extensive plant at their larger premises.

Further details of these units are available from Kingsbourne Products Ltd.

Portable Demineralizing Plant

THE advantages of using water free of dissolved solids, or other contaminants, in the make-up of electroplating solution is now widely recognized.

Distilled quality water without use of heat or power is obtained from the new Mark V Portable "Deminrolit" plant, introduced by The Permutit Co. Ltd., Gunnersbury Avenue, London, W.4. Incorporating a dial type conductivity tester and supplying up to 6 gallons of pure water hourly, the Mark V Portable (Fig. 2) is particularly suitable for laboratory and small process work.

Basically, the Mark V consists of two columns of ion-exchange material. When raw water is passed through the first column containing Permutit "Zeo-Karb" cation exchange material, the mineral salts in the raw water are converted to their corresponding acids. These acids are then passed down through the second column containing Permutit "De-Acidite" ion-exchange material which absorbs the acid. The demineralized, or de-ionized, water which results from this process is of distilled quality.

Fig. 2.—Portable demineralizing plant.

The Mark V Portable is easy to operate, thoroughly reliable, and the only running costs involved are the small quantities of acid and alkali required for regenerating the ion-exchange materials.

The Permutit "Zeo-Karb" and "De-Acidite" ion-exchange materials are of proved quality and robust—assuring the Portable a long effective life.

Protective Coating in Aerosol Pack

A HARDENED resin-type of lacquer, packed in an aerosol container for use in industry is announced by Amber Oils Ltd., 11A Albemarle Street, London, W.1. When sprayed on metal surfaces the lacquer, known by the name Ruby, forms a hard corrosion-inhibiting coating, which is red in colour for easy examination and economy of application.

This coating is strongly resistant to scuffing and abrasion, and will not crack on exposure to heat and moisture. Once applied, it will remain intact for a very considerable period. It can, however, be removed by such readilv available solvents as paraffin or white spirit. One tin of Ruby will give a guaranteed minimum coverage of 150 square feet.

In a product evaluation test recently carried out, sample pieces of shim steel were vapour degreased, sprayed with one coat of Ruby and suspended by iron wires in various positions subject to outside atmospheric conditions, inside atmosphere, acid fumes, acid fumes and dampness, mild acid solution, and alkali fumes and water vapour. The test indicated that Ruby gave protection against fairly severe corrosive conditions for a considerable length of time.

Ruby is recommended as the protective coating for machine-tool parts, spares, gauges, stores and all metallic parts exposed to corrosion, or consigned for export.

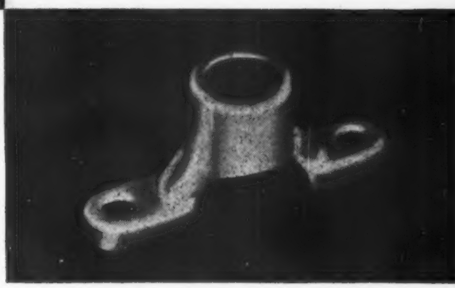
Surface-active Agents of High Stability

SURFACE active (wetting) agents are effective at very low concentrations (often only 0·01 per cent.) for improving the efficiency of many wet metal treatments, in which by reducing the surface and interfacial tension of the liquid they assist penetration, and at the same time improve drainage, thus reducing drag-out and carry-over and increasing the over-all speed of operation. These advantages are widely recognized, yet the use of such agents has hitherto been limited because they are seldom sufficiently stable in the strongly acid or

(*Continued in page* 224)

NOT TOO SMALL

For Hot Galvanizing



Through modern pre-occupation with the large and spectacular, we often forget the vital importance of the little things—the nails, washers, nuts and bolts which keep the parts together. These, not less than the main steel structures need hot galvanizing—the best way of ensuring long term protection at a reasonable cost. Few articles are too small to be treated. Up-to-date methods of centrifugal galvanizing allow small parts to be given a heavy and uniform coating of zinc. Threads as fine as those on a 5/16″ diameter bolt can be galvanized ready for use—with no subsequent cleaning required. Whatever the size of a part, large or small, it can usually be galvanized.

Hot Dip Galvanizers Association

The Hot Dip Galvanizers Association, a non-trading body, welcomes enquiries. Write to 34 Berkeley Square, London, W.1
Tel. Grosvenor 6636

Zn

Member of the Zinc Development Association

alkaline conditions common in metal treatment. Belloid M3 and Belloid M7 are non-ionic wetting agents specially developed by the Geigy Company Ltd., Rhodes, Middleton, Manchester, for use in these conditions. Their stability to acids, alkalis and oxidizing agents is far higher than that of most anionic or cationic, and even of many non-ionic, surface active agents. They are readily soluble in water at all concentrations, though they are normally used at rates as low as 0·01-0·05 per cent. Belloid M3, however, is somewhat less soluble in alkali at the high concentrations used in metal treatment, and is therefore more suitable for use in acid conditions. Belloid M7 can be safely used in strongly alkaline baths.

In acid pickling, cleaning and de-rusting baths Belloid M3 promotes attack on the corrosion products while attack on the basis metal itself is inhibited. Belloid M7 is similarly effective in alkaline baths, and is a powerful emulsifier of grease. Both are useful in rinsing and phosphate coating, and also in electroplating, where they improve the current efficiency of the bath and accelerate drainage.

Belloid M3 and M7 are available in the form of soft waxes, but, for convenience in view of the small amounts needed, they can also be supplied as aqueous solutions.

New Range of Stopping-off Tapes

THE range of Speedfix self-adhesive tapes, manufactured by Industrial Tapes Ltd., 142/146 Old Street, London, E.C.1, has lately been extended by a number of new technical tapes, some of which have characteristics of interest to the plating trade.

The stopping-off or masking-out of certain areas is very often essential during the plating process and the traditional method of performing this operation has been by immersion in high-temperature waxes, the parts to be plated being exposed by slicing away a part of the wax coating. While this method is effective it takes a considerable time to carry out.

Many production engineers have experimented with normal self-adhesive tapes in an endeavour to find a short cut on this production problem but standard commercial materials do not fulfil the ideal requirements.

The new Speedfix range has been developed taking into consideration the following requirements:—

1. Resistance to acid and alkaline solutions and to temperatures up to boiling point.
2. Extreme flexibility—to render the materials suitable for stopping-off uneven surfaces, slots, grooves, etc.
3. Freedom from chemical reaction between the adhesive and the metal surface.

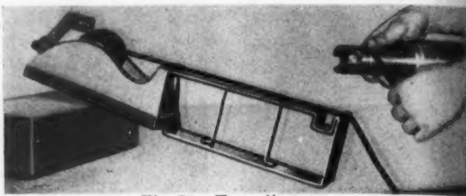


Fig. 3.—Tape dispenser.

4. Freedom from deposit when the adhesive is stripped away.

All of these requirements are fulfilled in a range of seven varieties of Speedfix stopping-off tapes. With the aid of these products stopping-off is reduced to a simple procedure of winding a suitable tape round the area to be masked and stripping it on completion of the plating process.

Sometimes the new tapes are used in conjunction with wax dipping in order to obtain a dead straight edge on an otherwise entirely wax covered unit. For this purpose some of the tapes are available in various colours so that the edge can be clearly seen through the wax coating.

The conditions which determine which of the above materials should be used are best determined by experiment. It is suggested that a small sample of each one of the range of materials is stuck down on a plate which is then put through a relevant cleaning and plating cycle.

Fuller details and samples of these tapes are available from the manufacturers.

For application of stopping-off tapes the Speedfix slicing dispenser (Fig. 2) is recommended. This enables any width of tape to be cut at will from 1/10 up to 2 in.

Rigid Polythene Containers

A NUMBER of new containers fabricated from polythene have been introduced by Tool Treatments (Chemicals) Ltd., Colliery Road, Birmingham Road, West Bromwich. This includes a 5-gal. stacking bin suitable for processing and storage of food and the handling of corrosive chemicals and fluids. It is a type of vessel particularly adapted to the needs of the plating trade.

The ingeniously-designed lid allows a completely lidded container to be stacked on top of it.

Also being introduced for the first time in high-density rigid polythene is a large stacking bin with a capacity of 10 gal., and a 2½-gal. bucket.

This is the first time that products of this type have been able to be produced in rigid high-density polythene. These products are more rigid than the flexible type of polythene and offer the additional and exceptional advantage that they can be sterilized in boiling water without any harm. The softening point of rigid polythene is 116° C with a melting point of 130° C and a low-temperature brittle point of —70° C.